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The Journal of
Bone and Joint Surgery

EDITORIALS AND ANNOTATIONS

HER MAJESTY THE QUEEN

Six years ago, when the *Journal of Bone and Joint Surgery* first became fully representative of the British Commonwealth of Nations as well as of the United States of America in "recording scientific progress and publishing new discoveries by all English-speaking peoples for the welfare of mankind" we had the very great privilege of receiving from His late Majesty a message from which these words are quoted.

To-day we acclaim with homage and devotion the coronation of our Queen, and we acclaim it with an assurance even greater than before that the English-speaking peoples are dedicated to the welfare of mankind. Indeed we are determined to show evidence of it in a reign that surely will be long and happy. Our responsibility is not light and our duty is not easy—but it can still be happy. May we therefore pay allegiance to Her Majesty the Queen in her year of coronation by saying that we too will try to accept responsibility with joyfulness.

SPINAL FUSION

It is interesting and perhaps useful to review procedures that are an accepted part of the stock-in-trade of the orthopaedic surgeon. Spinal fusion has become a relatively frequent operation in major orthopaedic centres during the last twenty-five or thirty years. Even so, not many individuals do the operation often enough in the course of a surgical career to produce a statistically significant series of long-term results. This being so, there is a natural tendency to establish a hospital or clinic technique, and to practise it whenever spinal fusion is required; this factor is also to some extent responsible for a healthy reluctance to give up accepted methods for new and untried procedures.

Ollier in 1867 described a method of bone transplantation using an osteoperiosteal graft. This was the beginning of attempts to join segments of the spine to arrest disease and to alleviate pain. Since then many distinguished surgeons have made their contribution to the subject. The most notable, in relation to the original nature of their contributions, were Albee—for the motor saw which permitted cutting and shaping of cortical grafts, and Hibbs—for the method in which "ankylosis" could be obtained without the introduction of any "outside" bone. In 1921, when the first Commission was appointed by the American Orthopaedic Association to investigate "the results of ankylosing operations on the spine" the only two methods in common use were those introduced by Albee and Hibbs, and the only condition for which the procedure had been carried out in sufficient numbers to merit investigation was Pott's disease. The method of posterior spinal fusion has been modified in various ways since then, but the modifications have been matters of detail rather than of principle. Methods of fusion of the vertebral bodies had been suggested by others, but the procedure was first carried out by Burns in 1933 for spondylolisthesis.

Modification of methods of fusion has naturally been accompanied by exploration of alternative materials to autogenous bone as an aid to the process. The materials worthy of mention are beef bone, os purum and os novum, and homogenous bone. Though these other

substances had extensive clinical trials, it was generally accepted before the last war that autogenous bone was by far the best material. This state of affairs has been to some extent modified by the great increase in the use of homogenous bone made possible by the use of the bone bank. Even now, years after the first reports of the method, it is still difficult to assess accurately the relative merits of autogenous bone and homogenous bone from the bank in spinal fusion. Any such assessment must take into account not only the incidence of failure of fusion after the use of each substance, but also the symptoms and scars created by the removal of autogenous grafts.

In a recent report on spinal fusion Wilson stated that in his experience homogenous and autogenous bone had shown little difference in healing time, though from the results quoted it is evident that, using the same technique, autogenous bone was more satisfactory than bone from the bank. Of forty-six patients there was failure of fusion in three, and in all these banked bone had been used. The proportion of autogenous bone to banked bone in the series was approximately 3 : 1. The results of the establishment in Holland of a national bone bank, in which calf bone is used and from which grafts of any shape or size can be obtained to order, will be awaited with much interest.

The accepted indications for spinal fusion have changed considerably in the last twenty years. More spinal fusions are now done for traumatic, congenital and degenerative lesions, and less for specific infections. This tendency has progressed along with a persistent effort to cut down the period of post-operative immobilisation. Whenever the post-operative immobilisation is inadequate the proportion of failures increases, and this matter of "adequate" immobilisation has always been a vexed one. In this connection the value of metal fixation in the form of screws and plates bolted on, as a method of doing away with other forms of immobilisation, is very much on trial. Public reports are encouraging, though unofficial comments on the methods are not always so favourable. This tendency to decrease the period of post-operative immobilisation has to some extent come into conflict with the changing indications. The greater the mobility of the segment of the spine to be fixed—before operation—the more effective must be the post-operative fixation. It must also be proportional to the strain thrown on the graft—in a "straight" spine this will increase from above downwards. Hence the preoccupation with lumbo-sacral fusion as the main problem in spinal fusion; it is most frequently called for and most difficult to obtain. The strains and stresses put on a graft for scoliosis are still in the realms of conjecture. Pseudarthrosis is relatively infrequent in this condition, because all agree that a long period of post-operative immobilisation is essential.

There must be few operations in which assessments of published results have shown such wide variations; the spine is an area of the body about which enthusiasms wax and wane. For example, in 1923 a series of 221 spinal fusions, carried out mostly for tuberculous disease, was published, in which it was claimed that there was failure of fusion in only one! In a similar series published in 1951, 25 per cent were found to have a pseudarthrosis. The difference can be attributed to improvement in radiographic technique, and to acceptance of the fact that radiographs in two positions are essential in estimating fusion. Objectivity in analysis perhaps plays some small part!

In this number of the Journal we report two new methods of fusion. Each is a modification of methods previously described. James and Nisbet describe a "body to body" fusion through a posterior approach. This is based, apart from the obvious mechanical desirability of fusion of the bodies, on two main indications. One is that in spondyloisthesis the detached lamina and spinous process should be removed. This is an interesting observation, and one which may have a wider application than is immediately apparent. In a personal series of disc explorations and spinal fusions done over the last seven years each patient has had peripheral signs of root irritation, and has been relieved by removal of the appropriate spinous process and lamina, followed by spinal fusion. In none was prolapse of disc material found at operation.

The second indication is that both in spondylolisthesis and degenerative lesions the disc should be curetted at the time of fusion. This is probably an unnecessary procedure, provided sound bony fusion is achieved, and this cannot be done simply by curettage of the disc. James and Nisbet hope to improve on a quoted figure of 17 per cent pseudarthroses, and their results are promising. However, as they rightly point out, theirs is a preliminary report, and they have much more to do before the figures will be statistically significant. We must remember that this operation is one of election, and therefore must be done in such a way that not only is the desired result obtained, but that complications are reduced to the minimum.

McKee, in another paper in this issue, describes a new technique for fixing the grafts at the time of operation. The efficiency of the method will depend on how firmly the "match stick" grafts can be held by the rings, and whether the process of assimilation of the grafts will alter their size sufficiently to affect the hold that the ring exerts; also, and perhaps more important, at what stage in the process of fusion this change takes place. These are questions that could be answered only by exploration at intervals after the primary operation. What effect the tight binding together of these small grafts might have on the rate of their reorganisation is a question of some interest.

If it could be demonstrated conclusively that heterogenous bone grafts with metallic or mechanical internal fixation can produce uniformly satisfactory results in low lumbar fusion for degenerative conditions—thereby eliminating the need for removal of bone from other sites, and for keeping patients in bed for long periods after operation—it would be the passing of another milestone on the long road of progress in surgery. The milestone may be in sight, but it is still ahead.

J. C. Scott.

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THE ROLE OF SYMPATHECTOMY IN THE TREATMENT OF CAUSALGIA

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Although the holocaust of two world wars has provided ample opportunity for further study, causalgia remains an enigma, for its pathogenesis is still obscure and the treatment by sympathectomy largely empirical. In this paper some of the current theories of the pathogenesis of causalgia will be reviewed and an attempt made to explain the role of sympathectomy in the relief of pain. These observations are based on a study of forty-eight patients treated in various peripheral nerve injury centres in Great Britain, and the author is indebted to the surgeons working in these centres for the use of their detailed case reports.

CLINICAL FEATURES

In all the patients causalgia resulted from an incomplete lesion of one or more nerve trunks. The pain usually had a burning quality, was situated in the hand or foot and was aggravated by physical and emotional stimuli. In the latter respect causalgia differs from all other painful states arising from a nerve injury. Noise, high notes, low-flying aeroplanes, or a child's cry often provoked a severe spasm of pain. Excitement and worry were badly tolerated and many of the patients complained that they did not enjoy a sensational film or an exciting novel. Some of the patients acquired reclusive habits and spent the greater part of the day sitting or lying in a corner of the ward.

TABLE I

TIME OF ONSET OF PAIN AFTER WOUNDING

(Forty-one cases in which a clear record was made)

Within twenty-four hours	26
Second to seventh day	9
Second to fourth week	5
Over one month	1

The pain usually commenced within a few hours of wounding (Table I) and often increased slowly in severity over the first few days. Sometimes, after a period varying from a few months to a year or more, there was a slow but steady improvement in the pain, though for several years after wounding many patients still complained of twinges of pain when they were excited or during hot weather.

The trophic and vascular changes were a striking feature but were very variable. In some patients the skin of the hand or foot was warm and glossy, in others it was cold and clammy.

THE NERVE LESION

There was a striking similarity in the pattern of the nerve injury in the arm and leg. The main features were as follows (Tables II and III):

1) There was always an incomplete lesion of the brachial plexus, or median nerve in the arm, and of the sciatic, medial popliteal or posterior tibial nerves in the leg. In some of the cases there was only a transient motor paralysis, and by the time the patient arrived at the

nerve injury centre the only evidence of neural injury was pain and hyperalgesia in the sensory distribution of the nerve. Even in the few cases in which, at the time of operation, all muscles were paralysed distal to the injury there was always a lesion in continuity of the nerve with varying degrees of intraneural scarring, and in every case there was some subsequent motor recovery. These findings conform with those of Shumacker, Speigel and Upjohn (1948), and many other authors. Causalgia must be a rare complication after complete division of a peripheral nerve and reports of its occurrence require critical examination, as in the following case: A patient was referred for examination with a diagnosis of ulnar nerve causalgia.

TABLE II

ANALYSIS OF NERVE INJURY IN UPPER LIMB
(Twenty-seven cases)

Type of lesion	Number of cases	Level of lesion	
		Above elbow joint	Forearm
Median	4	4	
Median Ulnar*	12	11	1
Median Ulnar Radial†	9	9	
Brachial plexus	2	2	—

* In three of the twelve patients the ulnar nerve was completely divided.

† In one patient the radial nerve was completely divided.

None of the remaining nerves was severed.

TABLE III

ANALYSIS OF NERVE INJURY IN LOWER LIMB
(Twenty-one cases)

Type of nerve lesion	Number of cases	Level of lesion	No.
Medial popliteal	18	Buttock	3
		Thigh	11
Lateral popliteal		Popliteal fossa	4
Medial popliteal	2	Popliteal fossa	2
Posterior tibial	1	Middle third of leg	1

None of the above nerves was severed.

Clinically there was complete ulnar palsy and at operation the nerve was seen to be severed. The only evidence of a median nerve lesion was pain and hyperalgesia in the median area of the hand, yet the pain was abolished for four hours by blocking the median nerve at the wrist with 2 per cent procaine.

2) Multiple nerve lesions were common and the pain was often associated with more than one nerve. In the upper limb this was verified by blocking consecutively the ulnar nerve at the elbow and the median nerve at the wrist. Three patients with an incomplete lesion of the median and ulnar nerves were investigated in this manner. In two patients blocking the ulnar and median nerves in succession caused relief of pain in their respective areas in the hand, but in the third patient the nerve blocks did not relieve the pain, though they did in some way alter its character.

3) All the nerve injuries were caused by bomb or shell splinters or high velocity missiles, and with two exceptions all the lesions were at or above the level of the knee and elbow.

Ulmer and Mayfield (1946), Sunderland and Kelly (1948), and many other writers have drawn attention to the rarity of causalgia after a nerve lesion in the distal part of a limb. It is unlikely that the greater incidence of causalgia in high lesions is connected with any particular relationship between the numbers and arrangement of sympathetic and sensory fibres, for most of the sympathetic and almost all the sensory fibres leave the nerve trunks distal to the wrist and ankle. In most of the cases there was a dual nerve injury, and this probably explains the preponderance of high lesions. In the lower limb the medial and lateral popliteal nerves are usually joined to form the sciatic nerve down to the level of the lower third of the thigh, and they are closely related in the popliteal fossa. Below this point they diverge and therefore there is less risk of an injury to both nerves. The same considerations apply in the upper limb. Here the median and ulnar nerves are closely related in the upper two-thirds of the arm; below this level they diverge, again reducing the chances of a dual injury.

It is generally agreed that causalgia is a rare complication of an incised wound of a nerve. Puckett, Grundfest, McElroy and McMillen (1946) have demonstrated that when a high velocity missile passes close to a nerve the latter is subjected to a considerable degree of stretch, which cannot occur when a nerve is cleanly divided. A stretch injury of this type may cause various degrees of damage to the neuraxons and degeneration of their myelin sheaths. Granit, Leksell and Skoglund (1944) have demonstrated that in these circumstances an artificial synapse may be formed, which allows impulses to pass between the various nerve fibres at the level of injury. This has an important bearing on the pathogenesis of causalgia and is discussed later.

TREATMENT

Of all the maladies that may afflict man causalgia is one of the most painful, and effective treatment should be instituted at the earliest opportunity, not only to allay intolerable suffering but also to prevent the crippling deformities of the joints which follow long continued voluntary immobilisation of the painful limb.

TABLE IV

EFFECT ON PAIN OF GANGLION BLOCK
(Thirty-six cases)

	Relief	Incomplete relief	No relief
Complete block	27	4	1
Incomplete block		—	4

A review of the literature which has appeared during and since the last war, and the experience of surgeons working in the nerve injury centres in Great Britain, leave one in no doubt that sympathectomy is the only form of effective therapy in a severe case of causalgia. Many other methods of treatment were employed in the centres. They included freeing of the nerve from scar tissue (neurolysis), resection of the damaged segment, periarterial sympathectomy, and radiotherapy; and although each of these appeared to relieve pain in isolated cases the effect was never dramatic, and might well have been unrelated to the treatment.

Before considering sympathetic denervation of the upper or lower limb it is wise to ascertain the response to procaine or other block of the appropriate sympathetic ganglia (Table IV). In the upper limb it is necessary to infiltrate only the second thoracic ganglion, but it is usual to include the stellate because the appearance of Horner's syndrome is additional confirmation of a successful injection. In the lower limb it is usual to infiltrate the second,

third and fourth lumbar ganglia. With practice these procedures are not difficult but the results must be interpreted with caution. A complete block of the sympathetic ganglia cannot be assumed unless there is complete anhidrosis of the limb and an appreciable increase in the warmth of the hand or foot. These effects should appear within five to ten minutes of the injection. It is also important to ascertain that the block is confined to the sympathetic ganglia, for, if the somatic nerves are infiltrated inadvertently, it is impossible to say whether the relief of pain can be ascribed to the block of the sympathetic ganglia or the nerve trunks. A successful block of the sympathetic outflow to a limb often gave relief of pain for from one to three hours: failure to secure any relief after two successful blocks was regarded as a contra-indication to sympathectomy.

The potentialities of blocking the sympathetic ganglia by tetraethyl ammonium bromide were not fully investigated as the drug only became available after the war. It was used on three occasions, in doses of 300–400 milligrams. All the patients were relieved of pain and in one patient the pain did not return until two to three hours after the injection. It is possible that the longer-acting methonium compounds now available may be even more valuable in the pre-operative investigation.

With three exceptions every patient benefited from a sympathectomy. The failures were caused by technical difficulties during the operation and subsequent examination revealed that the sympathectomy was incomplete. The interval between wounding and the sympathectomy varied from five weeks to almost seven years. The long delay in securing treatment was due to the patients being held as prisoners of war but it did not prejudice the efficacy of sympathectomy.

In some patients the hyperalgesia persisted although there was complete relief of spontaneous pain. The persistent hyperalgesia was presumably caused by an "irritative" lesion of the somatic sensory fibres at the site of the nerve injury rather than an inadequate sympathectomy.

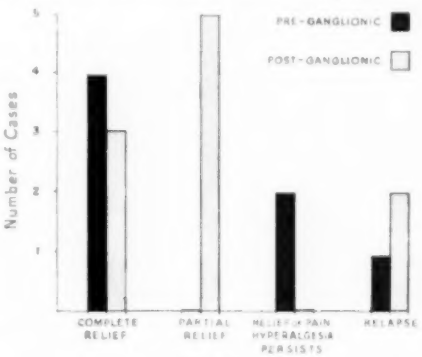

FIG. 1

Analysis of results of cervical sympathectomy for causalgia. Follow-up periods were: preganglionic section ten to forty-six months (average thirty-two months); postganglionic section two to forty-two months (average twenty-four months).

Results in upper extremity—Two types of sympathectomy were performed—cervico-thoracic ganglionectomy and preganglionic sympathectomy. In cervico-thoracic ganglionectomy the lowest cervical and first, or first and second, thoracic ganglia, and intervening trunk were removed. This operation, a post-ganglionic sympathectomy, does not produce as effective vasodilation of the limb as the preganglionic operation, and gives the patient a Horner's syndrome. In preganglionic sympathectomy (Smithwick 1940) the second and third thoracic ganglia were decentralised by dividing the white rami communicantes to each ganglion and the sympathetic trunk below the third ganglion.

On theoretical grounds these two procedures should be equally effective in the relief of pain but in practice this was not the case. A number of completely satisfactory results were obtained with both operations but there were more failures with the postganglionic operation (Fig. 1).

Of the eighteen operations performed three were failures, and in each of them it was known that the sympathectomy was inadequate because of technical difficulties at the time of operation. Six patients had a preganglionic sympathectomy, and were completely free of pain after the operation; four of them were also relieved of hyperaesthesia and hyperalgesia. In one patient the pain returned with warmth and excitement, one year after operation, and

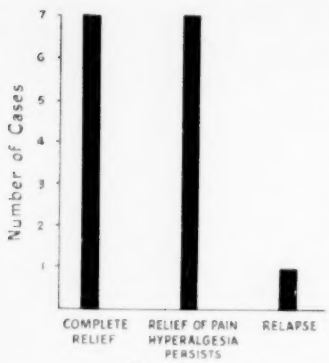

Fig. 2

Analysis of results of lumbar ganglionectomy for causalgia. Follow-up periods were up to eighty-four months (average twenty-three months).

appeared to be due to regeneration of the sympathetic fibres. Eight patients had a postganglionic sympathectomy. Three were completely relieved of spontaneous pain and hyperalgesia after the operation, and remained so during the follow-up period. In the remaining five patients there was considerable but not complete relief of pain and in three of them the hyperalgesia persisted with its original intensity. In one case no record was made of the type of sympathectomy.

Results in lower extremity—The results of sympathectomy were better in the lower limb than in the upper limb (Fig. 2). The operation consisted in the removal of the first, second and third, or second, third and fourth lumbar ganglia, and the intervening chain. Both are predominantly preganglionic sympathectomies, for the cell stations for the sympathetic fibres to the lower limb are situated in the third lumbar to third sacral ganglia.

Fifteen operations were performed: all patients were relieved of pain initially, but in four of them some pain returned during the first year after operation, and six still had some hyperaesthesia and hyperalgesia in the sole of the foot, which persisted for many months after the operation.

PATHOGENESIS

In spite of many investigations into the nature of causalgia no satisfactory explanation has been found, for none of the theories at present in vogue will explain all the observed facts.

Most workers agree that sympathectomy will relieve the pain in most cases and it is tempting to attribute this to the abolition of afferent pain impulses transmitted by the sympathetic nervous system (Bingham 1948). There are, however, serious objections to this hypothesis. It is impossible to demonstrate any change in the sensitivity of a limb which has been sympathectomised for peripheral vascular disease. Furthermore, lesions of the cauda equina are encountered from time to time in which the spinal nerves are damaged below the level of the sympathetic outflow; yet in spite of the normal sympathetic innervation there is complete loss of sensation in the lower limbs (Fig. 3).

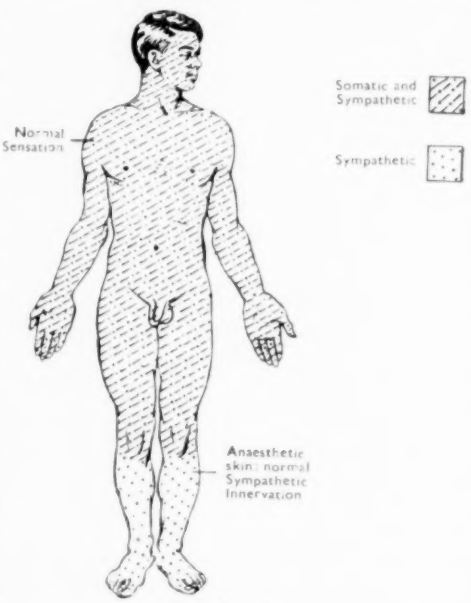

Fig. 3

Lesion of cauda equina distal to L 3 root. Although there is normal sympathetic innervation of the leg and foot there is complete analgesia in these areas.

In two patients a low spinal anaesthetic was administered with the intention of blocking the pain fibres from the lower limb and at the same time preserving the sympathetic innervation of the leg. This is possible because the lowest white ramus for the sympathetic chain is given off by the second lumbar nerve root (Figs. 4 and 5). One of the patients had severe causalgia after a sciatic nerve lesion at the level of the buttock. With the patient sitting, 3·5 cubic centimetres of 5 per cent procaine was

injected into the spinal theca. There was *immediate* relief of pain long before the preganglionic sympathetic fibres were paralysed, for there was no rise in the skin temperature of the big toe as measured by a thermocouple until eight minutes after the administration of the anaesthetic. The other patient had severe causalgia following a lesion of the medial and lateral popliteal nerves in the popliteal fossa. One cubic centimetre of procaine was injected into the spinal theca and complete anaesthesia was obtained up to the level of the third lumbar dermatome. The pain in the foot was abolished but the sympathetic outflow to the lower limb was unaffected as there was no rise in the skin temperature of the first and fifth toes.

From these observations it is reasonable to assume that the pain impulses are conveyed centrally by the normal sensory pathway and not by the sympathetic nervous system. These

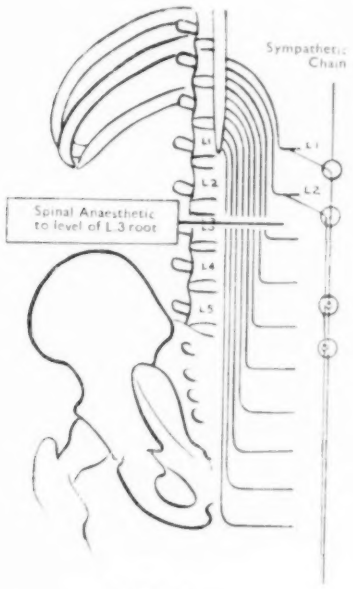

FIG. 4

The lowest white ramus to the sympathetic chain is given off by the second lumbar nerve root. Spinal anaesthesia to the level of the third lumbar root will abolish pain impulses from the lower three lumbar and sacral dermatomes without interfering with the sympathetic innervation of the lower limbs (see Fig. 5).

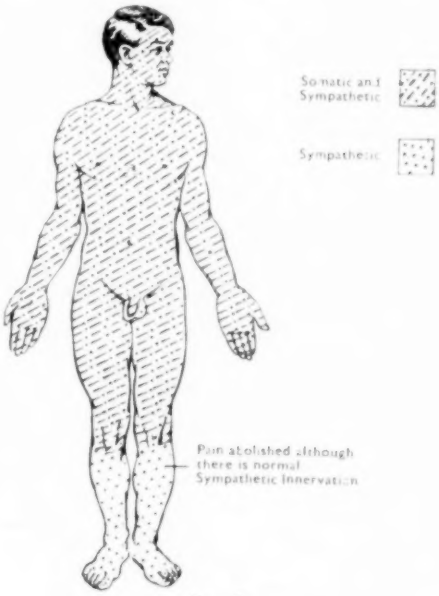

FIG. 5

Effect of a low spinal anaesthetic. The pain in the foot is abolished although there is normal sympathetic innervation, indicating that pain impulses are conveyed centrally by the normal sensory pathway and not by the sympathetic nervous system.

impulses cannot, however, originate in the afferent sensory fibres for the pain is relieved by blocking the sympathetic ganglia, which can have no direct effect on the sensory pathway (Table IV). We must assume, therefore, that sympathectomy acts by blocking efferent impulses in the sympathetic fibres, which in some way stimulate sensory afferent fibres at the site of the nerve lesion or at the periphery (Doupe, Cullen and Chance 1944).

We have now to consider how this occurs. Granit *et al.* (1944) have shown that an artificial synapse between motor and sensory fibres can occur at the cut end of a nerve, or even after a nerve injury which does not prevent normal distal conduction. Although these workers did not demonstrate a synapse between the sympathetic and sensory fibres there is no reason to suppose that it does not occur.

Causalgia cannot, however, be explained solely on the basis of an artificial synapse between sympathetic and sensory fibres at the site of the nerve lesion because the pain is sometimes relieved by blocking the nerve with procaine *distal* to the lesion (Table V). This observation led Doupe and his co-workers to postulate a distal causalgic syndrome in which the synapse between the sympathetic and sensory fibres was supposed to occur at the periphery of the limb when the nutrition of the nerves was impaired by oedema or ischaemia.

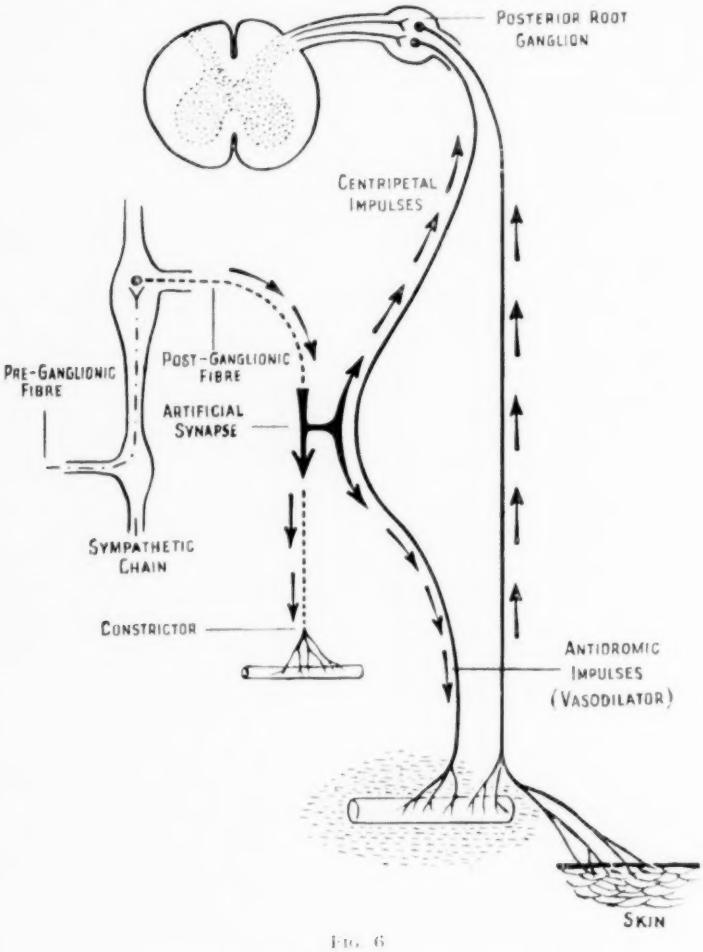

FIG. 6

Diagram of suggested pain pathway in causalgia.

A criticism of this supposition is that pain often commences within a few hours of wounding, before nutritional changes could have occurred (Table I).

Since causalgia seldom occurs when a nerve is completely divided, it seems probable that in most cases the preservation of distal conduction is essential to the development of the syndrome. If the artificial synapse between the sympathetic and sensory fibres occurs at the site of the nerve lesion, which is the only reasonable possibility, we must assume that impulses having "short-circuited" from a sympathetic to a sensory fibre can now pass up or down the sensory fibre (Fig. 6). The impulses travelling distally may cause the release of

a pain-producing substance at the periphery of the limb, or in some way lower the threshold of stimulation of the sensory nerve endings.

Lewis (1937) has shown that when the distal end of a divided sensory nerve is stimulated the skin it supplies becomes flushed and warm and that this may be accompanied by burning pain. This response to antidromic stimulation is very similar to the phenomena of causalgia. A criticism of the analogy is that all cases of causalgia do not show vasodilation, but we have no knowledge that "antidromic" vasodilation can be maintained indefinitely without compensating factors intervening: disuse will cause a large measure of cooling, and pain is known to cause vasoconstriction.

The clinical features of causalgia and the satisfactory response to sympathectomy can be explained on the basis of the following hypothesis. The nerve lesion is usually caused by the passage of a missile in its vicinity which results in a stretch injury without solution of continuity of the nerve or permanent loss of conductivity. The injury breaks down the insulation of the nerve fibres and an artificial synapse is established between the efferent sympathetic and afferent sensory fibres. Impulses passing down the sympathetic fibres are "short-circuited" to the sensory somatic fibres where they can travel both centrally and distally (antidromic) (Fig. 6). The antidromic impulses cause a substance to be released at the periphery, which either reduces the threshold of sensory stimulation, or *per se* sets up centripetal impulses in the sensory fibres which summate with those arising directly at the artificial synapse.

If this view is correct the onset of pain will usually be dependent on the return of normal conduction distal to the nerve lesion. Once the pathway is established pain will persist until effective insulation of the nerve fibres is restored which will prevent passage of impulses across the artificial synapse; or until such time as the efferent impulses in the sympathetic fibres are abolished by sympathectomy.

TABLE V

EFFECT ON PAIN OF NERVE BLOCK DISTAL TO LESION
(Fourteen cases)

Complete relief	8
Incomplete relief	2
No relief	4

The hypothesis explains the variable response to a nerve block distal to the lesion (Table V). A successful nerve block will abolish the centripetal pain impulses arising at the periphery of the limb. If these impulses are responsible for most of the pain considerable relief may be expected. On the other hand the nerve block will have little or no effect if the pain is caused chiefly by centripetal impulses arising at the site of the nerve lesion.

At first sight a serious criticism of this hypothesis is that resection of the damaged part of the nerve, which must interrupt both the efferent and afferent pathways, often fails to give complete relief of pain. The probable explanation is that there is usually a lesion of two or more nerves (Tables II and III). In these circumstances resection of one nerve will only relieve pain in the area of skin supplied by it alone, and pain will persist in the part of the hand or foot supplied by the other injured nerves. This undoubtedly accounted for the partial failure of resection on the three occasions it was employed in this series and the following case is typical of all three (Fig. 7): A man of thirty-one was wounded in the right upper arm by a mortar bomb splinter and sustained a lesion of the median and ulnar nerves. On the day after the injury he complained of pain "like severe toothache" in the right hand and less severe in the index finger and thumb. The pain was aggravated by coughing, sneezing,

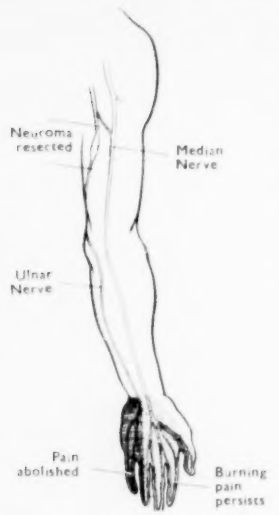

FIG. 7

Resection of the damaged portion of one nerve often gives only partial relief of pain, for if there is a lesion of two nerves pain will persist in the area of the hand or foot supplied by the remaining nerve or nerves.

deep breathing and emotional stimuli. When he was examined seven weeks after injury there was marked weakness of all muscles supplied by the ulnar nerve and slight weakness of the median intrinsic muscles. Sensory testing was difficult but there appeared to be loss of sensation to light touch in the median and ulnar nerve areas, and pinprick caused diffuse burning pain. At operation three months after injury the median nerve was freed from scar tissue and a small lateral neuroma was excised. There was a large neuroma on the ulnar nerve; this was resected and a suture performed after anterior transposition. The day after operation pain returned to the median area of the hand but it was abolished in the ulnar area. Two months later the pain was completely relieved by a preganglionic sympathectomy.

SUMMARY

1. Forty-eight cases of causalgia are reviewed and the clinical features are briefly described.

2. Multiple nerve injuries are common and the pain is often associated with all the injured nerves. In the upper limb there was always an incomplete lesion of the lower trunk or medial cord of the brachial plexus, or of the median nerve. In the lower limb there was always an incomplete lesion of the medial popliteal division of the sciatic, the medial popliteal, or the posterior tibial nerve. These nerves carry most of the sympathetic fibres to the hand and foot. With two exceptions all the nerve lesions were at or above the level of the knee or elbow.

3. Sympathectomy gives marked relief of pain in most cases of causalgia. Prompt treatment is essential to prevent the crippling deformities which follow prolonged voluntary immobilisation of the painful limb. The results of preganglionic are superior to those of postganglionic sympathectomy.

4. The possible pain pathways are discussed, and an explanation is offered for the successful results of sympathectomy in the treatment of causalgia.

The author is indebted to Mr G. Donald, of the Department of Surgery, Glasgow University, for the illustrations accompanying this article.

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POSTERIOR INTERVERTEBRAL FUSION OF THE LUMBAR SPINE

Preliminary Report of a New Operation

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This is a preliminary report of a new operation by which to stabilise a segment of the lumbar spinal column by body-to-body fusion through a posterior approach. It has been used in the treatment of six patients with spondylolisthesis, the procedure in these cases including excision of the separated neural arch which we believe to be an important part of the surgical treatment of painful spondylolisthesis. It has also been used in five patients who had severe low back pain persisting after the operative treatment of prolapse of intervertebral discs. We recognise that eleven cases is a small series, and that the period of follow-up is short; but several patients have now been under review for more than two years and our experience has been so satisfying that we feel justified in publishing a preliminary report. The principle of the operation is essentially the same in each of these two groups of cases but they must be considered separately because in spondylolisthesis there are special problems.

POSTERIOR INTERVERTEBRAL FUSION IN SPONDYLOLISTHESIS

In spondylolisthesis the defect of ossification is at the isthmus of the vertebral neural arch—the slightly constricted area lying between the superior and inferior facets, and not at the neurocentral suture (Fig. 1). Usually the fifth lumbar vertebra is involved, sometimes the fourth, and occasionally the third (in our own recent series the corresponding number of cases being eleven, four and two).*

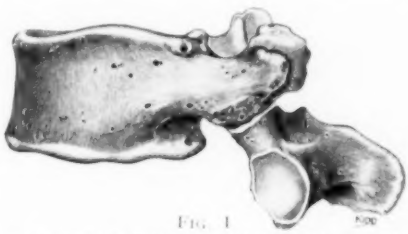

FIG. 1

A drawing of the fifth lumbar vertebra. The site of the lesion in spondylolisthesis is at the isthmus of the neural arch. (Diagrammatic.)

The symptoms include low lumbar backache in the midline, radiating pain in the buttocks and thighs, and sciatica. It seems probable that midline pain in the low back is the consequence of impingement of spinous processes and strain of interspinous ligaments, and that widespread pain radiating to the buttocks and thighs may arise from the stretching of anterior and posterior longitudinal ligaments and the annulus fibrosus; but the sciatica is more difficult to explain. Dandy (quoted by Mercer 1947) and Meyerding (1941) said that sciatica in spondylolisthesis was caused by herniation of the intervertebral disc, and many others have supported this view. We can say only that although this may sometimes be true it was not the cause of sciatica in any of our cases; on the contrary the intervertebral space was narrowed by degenerative changes in the disc, and great difficulty was experienced in gaining entrance.

We think that there is another explanation for the referred sciatic pain of spondylolisthesis, and the technique of our operation depends partly on this. Sciatic pain, often bilateral and symmetrical, can be induced by applying firm pressure over the spinous process of the affected

* It would be inappropriate in this communication to discuss the cause of spondylolisthesis; we refer readers to the classical studies of Manners-Smith 1909, Willis 1923, 1924, 1931, 1932, Capener 1932, Speed 1938, Batts 1939, Friberg 1939, Cleveland, Bosworth and Thompson 1948, and Harris 1951.

vertebra; indeed in one patient the pain so produced was agonising and he fell to the ground. Other patients have noticed that leaning back against a chair or rail gave rise to sciatic pain, presumably for the same reason. Our dissections, the models based upon them (Figs. 2 and 3) and the findings at operation, show that the separated Y-shaped neural arch can be so rocked on its articulations that the antero-superior margin impinges upon the nerve roots emerging below the pedicle of the defective vertebra. This surely is the explanation of the sciatic pain produced when pressure is applied to the spinous process of the affected vertebra; and it would also explain the complete relief from backache and sciatica that was gained by a dental student whose separated neural arch was excised without any other treatment at all (Fig. 4).

FIG. 2

FIG. 3

Figure 2.—Photograph of a fifth lumbar spondylolisthesis reconstructed from dry bones. The original neural arch was replaced with an operation specimen (the same as in Figure 4). When it is rocked on its articulations the separate neural arch impinges on the fifth lumbar root. In Figure 3 the separate neural arch has been removed to show the spinal theca and nerve roots. Note the vulnerable position of the fifth lumbar root.

At first it seems remarkable that the neurological signs in spondylolisthesis are so few. There is seldom evidence of nerve root compression such as accentuation of pain by coughing, sneezing, jugular compression or straight leg raising; and although tendon reflexes are sometimes less brisk than is normal, dermatomal hypalgesia is not elicited. Even when the fifth vertebral body has slipped off the sacrum—the grade four deformity of Meyerding (1934)—there may be fewer physical signs of neurological disturbance than in milder displacements. Search of the literature has failed to reveal any clear evidence of compression of the cauda equina; even the case reported by Ryerson in 1915 was open to doubt as to the nature of the intermittent paralysis. Harris (1951) said that the neural foramen was narrowed

by vertebral displacement so that the fifth lumbar root was compressed, but we have difficulty in accepting this. As the body of the fifth lumbar vertebra slips forwards on the sacrum the neural canal and foraminae increase in size, the root tends to slacken and the canal is decompressed. The first sacral roots are vertically disposed to the lumbo-sacral joint, and in spondylolisthesis at the fifth lumbar level they are often stretched over the top edge of the

FIG. 4

Photograph of a fifth lumbar separate neural arch excised at operation. The patient, a young dental student, was relieved completely from backache and sciatica by excision of the arch only. Pressure on the fifth lumbar root had caused sciatica.

sacral canal. The deformity occurs very gradually and the nerve roots, which are well padded with fat and many veins, accommodate themselves to the new position and suffer no damage. The alarming appearance shown in many radiographs has therefore little significance except in the few cases in which there is actually root pain.

Consideration of operative measures.—The vertebral displacement of spondylolisthesis is often discovered accidentally in the course of routine radiographic examination. Post-mortem anatomical studies show that the lesion is present in more than 5 per cent of skeletons, but far less than this proportion of patients with spondylolisthesis have clinical disability; in fact most of them have no symptoms at all. Only when there are persistent symptoms of low back pain and root pain should operative treatment be considered.

The principle of stabilising a segment of the spine by fusing the vertebral bodies rather than the laminae and spinous processes is attractive and logical (Mercer 1947, and Dandy quoted by Mercer). Animal experiments by Haas in 1946 showed that it could be accomplished in dogs. The anterior route was used successfully by Burns (1933), Jenkins (1936), Speed (1938) and Mercer (1947); but recently Law (1950) said that the anterior approach for lumbo-sacral fusion had been abandoned in favour of posterior spinal fusion. There are certainly drawbacks to the anterior approach. An abdominal operation is needed; the exact nature of the lesion cannot be seen; such primary causes of pain as nerve root adhesion, disc protrusion, or interarticular arthritis may be overlooked; and the separate neural arch cannot be excised, which we believe to be important.

Dandy, believing that the symptoms of spondylolisthesis arose from herniation of the intervertebral disc rather than from deformity or displacement, advised that the disc should be curetted; he thought that the resulting fibrous ankylosis would suffice to stabilise the

weak segment. Mercer (1947) in quoting this, suggested that the disc space might be packed with bone chips but did not say whether or not he had done it.

Fusion of the lumbar spine by the posterior approach as described hitherto has proved to be an arduous procedure with uncertain results (Harris 1951). Cleveland, Bosworth and Thompson (1948) said that in a series of sixty-five lumbo-sacral fusions there was failure in 3 per cent, but that when the fourth lumbar vertebra was included in the fusion, as it must be in spondylolisthesis, the failures rose sharply to 17 per cent. It is true that not all patients with pseudarthrosis after spinal fusion have persistent symptoms, but there is surely room for improvement in the operative technique.

Posterior intervertebral body-to-body fusion is a neater operation; with proper teamwork it is no more exacting than the operation of curetting the intervertebral disc; and it is a

FIG. 5

FIG. 6

Drawings illustrating the operation. The separate neural arch has been excised. In Figure 5 the dura mater is shown constricted to display the tibial grafts, seen end on, between the vertebral bodies. In Figure 6 the spine is represented diagrammatically as seen from the side. Care must be taken to ensure that the grafts penetrate the intervertebral space far enough. Note how the depth of the intervertebral space is maintained. The area formerly occupied by the separate neural arch is indicated.

positive-pressure arthrodesis—the two vertebrae being locked together at the fulcrum of movement. The grafts are subjected to pressure and they cannot fracture. Later, weight-bearing function may assist still further in maintaining the position and promoting the fusion of the grafts. Only in one case did a graft slip backwards, with recurrent sciatica; the displacement was detected easily in radiographs and corrected by nibbling off the projecting part.

The operation of posterior intervertebral fusion for spondylolisthesis—The patient is placed in the prone position, the hip joints being flexed to reduce the lordosis. To get a bloodless field the table is broken so that the lumbo-sacral area is at the highest part. Recently, hexamethonium compounds have been used to reduce the bleeding still more. The spines and lammae above and below the lesion are exposed through a midline incision. The spine of the separate neural arch is identified by its excessive mobility, and the separate neural arch is completely excised. The disc space is then revealed by gentle retraction of

the dural sac and nerve roots. The lumbo-sacral space slopes at such an acute angle from the vertical that entry is often difficult and the prominent margin of the sacrum may need to be removed with an osteotome. The disc contents are then curetted thoroughly. A mortise is cut into each vertebral body with a narrow chisel and, while the spine is flexed with the vertebral bodies levered apart, the size of the mortise is measured carefully. Two tibial grafts cut to this dimension are driven into the disc space, one on each side of the posterior longitudinal ligament (Fig. 5). Care should be taken to ensure that the grafts penetrate the intervertebral space deeply enough (Fig. 6); backward projection of the grafts can easily be removed with rongeurs. Once the grafts are in position this segment of the spine should become completely rigid. The nerve roots fall back into their normal position and do not lie in contact with the grafts. After haemostasis has been secured the wound is closed in layers.

After care—The patient remains in bed for three weeks and is then allowed up in a plaster jacket which is retained for two months. In earlier days some of our patients were immobilised in a plaster bed for three months but no advantage seems to have been gained by this. Radiographic examinations were made at three- and four-monthly intervals. The compact bone showed almost no absorption and the grafts retained their depth and position remarkably well. The appearance of bony striae between the vertebral bodies and grafts was long delayed and at first it seemed that only sound fibrous union would be gained; but as time passed the grafts became incorporated into the vertebral bodies, more readily into the body above than the one below (Figs. 7 to 9). We do not yet know that the grafts will always fuse soundly by bone to both vertebrae—but in the "movement studies" we have made, taking lateral radiographs in the positions of full flexion and full extension, there has always been complete stability of the segment even when evidence of continuity of bone striae between graft and vertebra was equivocal.

Clinical assessment of results—Of the six patients with spondylolisthesis who were treated by posterior intervertebral fusion, four gained complete relief from all symptoms and were able to pursue their ordinary duties; one still had slight pain but was much improved and able to do housework; one continued to complain of many symptoms and the result was bad but there were complicating factors of a drawn-out claim for compensation and many of the symptoms were thought to have a neurotic basis, although it must be admitted that radiographic studies in this patient cast doubt on the soundness of fusion.

POSTERIOR INTERVERTEBRAL FUSION AFTER CURETTING A PROLAPSED INTERVERTEBRAL DISC

From the reports of many series of cases of prolapsed intervertebral discs treated by curettage alone it is becoming evident that spinal fusion is seldom needed. O'Connell (1950), reporting a series of 500 operations, showed that cure, or at least very great alleviation of symptoms, was gained by excision and curettage of the disc alone in more than 90 per cent of patients; there was usually sound fibrous ankylosis of the intervertebral joint. From this and many other reports it is evident that recurrence of low back pain and sciatica usually arises from incomplete removal of the disc material, herniation of another disc at a different level, or post-operative adhesions. An increasingly small number of patients with prolapse of an intervertebral disc seem to need spinal fusion as well as curettage of the disc. We have done the operation of posterior intervertebral fusion by driving two grafts into the adjacent vertebral bodies through a posterior approach in five patients—all men. In this group of cases the results have been very satisfying. Every patient has been relieved of his symptoms and all are now back at work.

SUMMARY

1. A new operation of body-to-body intervertebral fusion by grafts introduced through a posterior approach is described. This is a preliminary report of early results, with follow-up to two years, which seems to be encouraging.

FIG. 7

Radiograph one year after intervertebral grafting for spondylolisthesis. The grafts were rather too short but nevertheless they have become soundly fused to both vertebral bodies and the symptoms are completely relieved.

FIG. 8

FIG. 9

Post-operative radiographs in a case of L.4–5 intervertebral fusion for fourth lumbar spondylolisthesis. The grafts are not yet soundly incorporated with the fifth lumbar vertebra.

2. In spondylolisthesis, abnormal mobility of the loose posterior neural arch is believed in itself to cause nerve root pressure, and excision of the arch is an important part of the operation.
3. In the few cases where spinal fusion is needed after removal of a prolapsed intervertebral disc—and the proportion is now very low—posterior intervertebral fusion has proved very satisfactory.

We take pleasure in thanking Mr Murray A. Falconer, the first Lecturer in Neurosurgery, University of Otago, who allowed us to use his early cases; Mr Renfrew White, Mr J. C. McNeur, and Mr H. Walden Fitzgerald, who have performed several of the orthopaedic steps of the operations and have assisted with the selection of the patients. We are grateful to Dr Charles A. Begg, who undertook the special radiographic examinations, to Miss D. Marshall and staff of the Photographic Unit of the Otago Medical School for the reproductions, and to Miss L. North and Miss E. Madigan for their capable secretarial aid.

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THE TREATMENT OF SUBCAPITAL FRACTURES OF THE NECK OF THE FEMUR WITH A NAIL-PLATE AND WEDGE OSTEOTOMY

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This paper describes the treatment of the more vertical type of subcapital fracture of the neck of the femur by reduction, nailing, and immediate wedge osteotomy, with fixation by a plate attached to the head of the nail. Ten cases are recorded. As in other clinics, it had been found that the results of treatment, by the standard Smith-Petersen technique, of subcapital fractures of the neck of the femur with a low fracture-shaft angle were poor because many fractures failed to unite. In comparison, fractures with a more horizontal line generally united well after reduction and nailing. It was therefore decided that the type of treatment adopted should depend on the value of the fracture-shaft angle, and forty degrees was arbitrarily decided as the dividing line.

The importance of the fracture-shaft angle was first recognised by Pauwels (1935). Eyre-Brook and Pridie (1941) measured the angle between the line of fracture and the long axis of the femur and reported that "this (fracture-shaft) angle clearly outweighs every other factor and should control the treatment given." Per Linton (1944) came to similar conclusions. Thus it is generally recognised that the mechanical factors at work in a fracture of the neck of the femur are of first importance in obtaining satisfactory union.

PRINCIPLES AND TECHNIQUE OF OPERATION

Primary osteotomy at the time of nailing in order to increase the fracture-shaft angle has been recommended by King (1939, 1950), Eyre-Brook and Pridie (1941), and Per Linton (1944). Pauwels (1935) recommended that after waiting for absorption of the femoral neck to take place, an osteotomy of the wedge type should be performed and the hip immobilised in a plaster spica. Per Linton recommended osteotomy at the time of nailing followed by immobilisation in plaster for eight to ten weeks. For established non-union Dickson (1947) suggested a controlled osteotomy producing abduction of sixty degrees. King (1950) reported fifty cases of primary osteotomy and plate fixation of the two fragments. He performed a subtrochanteric osteotomy and by abduction of the lower fragment produced a high fracture-shaft angle; the lateral cortex of the shaft was impacted into the medulla of the upper fragment, and the medial cortex approached the pelvis.

The first two cases reported here were operated upon by Dickson's technique, but this operation is a severe one for an elderly person, and a simpler osteotomy gives a similar mechanical result. It was considered that abduction of exactly sixty degrees was not necessary for every case, but that the degree of abduction should vary with the measurement of the fracture-shaft angle. The ideal osteotomy should have the following virtues. 1) It should be easily and rapidly performed through the incision used for nailing. 2) It should be stable and not require fixation in plaster. 3) It should give an adequate and accurate degree of abduction of the lower fragment. 4) It should not prejudice any further reconstruction such as cup arthroplasty or the fitting of a plastic head to the femur in the event of aseptic necrosis. A plated intertrochanteric or subtrochanteric osteotomy is the easiest to perform through the incision used for nailing; and, to obtain abduction of the head and stability, a wedge osteotomy with the base laterally should be ideal, for by simply abducting the leg the bone surfaces are brought together. To estimate the length of the base of the wedge needed to obtain the desired degree of abduction, the transverse diameter of the femur at the level of the proposed osteotomy is measured, and then by a simple calculation the amount of bone

TABLE I

LENGTH OF BONE TO BE REMOVED AT THE BASE OF THE WEDGE FOR VARYING BONE DIAMETERS TO PRODUCE A GIVEN ANGLE OF ABDUCTION

	Angle of abduction required				
Diameter of bone (inches)	20 degrees	30 degrees	40 degrees	50 degrees	60 degrees
1·0	0·35	0·53	0·72	0·93	1·15
1·2	0·42	0·64	0·86	1·02	1·38
1·4	0·49	0·75	1·01	1·30	1·51
1·6	0·56	0·85	1·15	1·49	1·85
1·8	0·63	0·96	1·29	1·68	2·08
2·0	0·70	1·07	1·44	1·86	2·31
	Base of wedge in inches				

to be removed is obtained. In practice only three approximations need be remembered. For abduction of thirty, forty, or fifty degrees, the wedge has a base equal to half, three-quarters, or just less than the full diameter of the bone (Table I).

Technique—The fracture is reduced by the usual technique and the affected leg is fixed in a few degrees of medial rotation with light traction. A slightly valgus position of the head is aimed at. It is a mistake to attempt to judge the plane of the fracture without some medial rotation of the lower fragment, because the fracture surface is inclined forwards, a fact that has been stressed by Per Linton and others. Radiographs are taken to confirm reduction, and to obtain a measure of the fracture-shaft angle. *Insertion of the nail*—The usual lateral approach to the upper end of the femur is used. If osteotomy has been decided upon the trifin-nail part of the two-piece nail-plate is driven in over a guide wire inserted just below the trochanteric tubercle, and directed just below and behind the middle of the head (Fig. 1). The fracture surfaces are impacted. *The osteotomy*—The wedge osteotomy is done by a hand saw to ensure well fitting surfaces. A saw cut sloping downwards and medially is made as high as possible below the nail, and almost through the shaft. The length of the base of the wedge is marked out, and a further cut is made with the saw to form a wedge with the apex medially and just above the lesser trochanter (Fig. 1). The lower cut is made right through the bone, and the upper cut is then completed, allowing removal of the wedge of bone. The gap is closed by abduction of the limb (Fig. 2). *Fitting the plate*—The plate is fitted to the head of the nail and secured to the lateral side of the femoral shaft by screws. One-piece blade-plates were not used because the plate prevents easy performance of the osteotomy.

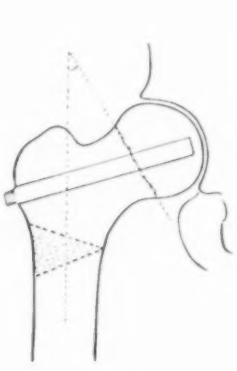

FIG. 1

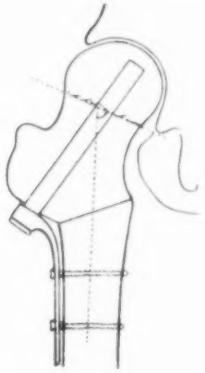

FIG. 2

Technique. Figure 1—The nail has been inserted and the position of the wedge is indicated. Figure 2—The wedge has been removed, the gap closed by abduction of the shaft, and the osteotomy fixed by nail-plate.

Post-operative treatment.—Skin traction is applied for four to six weeks, during which active movements of the knee and hip are encouraged. The patient is allowed up on crutches at two months, partial weight bearing is allowed after three months, and full weight bearing when there are radiological signs of union both of the fracture and of the osteotomy, usually at four months.

RESULTS

This series consists of ten cases. The first two patients were operated upon by Dickson's method for non-union. The next eight were consecutive patients with fresh fractures of low angle, operated upon personally in 1948 and 1949. The results are shown in Table II, and illustrative radiographs are reproduced in Figures 3 and 4. One death occurred from pulmonary embolism on the fourth day. In one case union appeared unsound. The poor result was attributed to technical errors, for the reduction and placing of the nail were imperfect, the

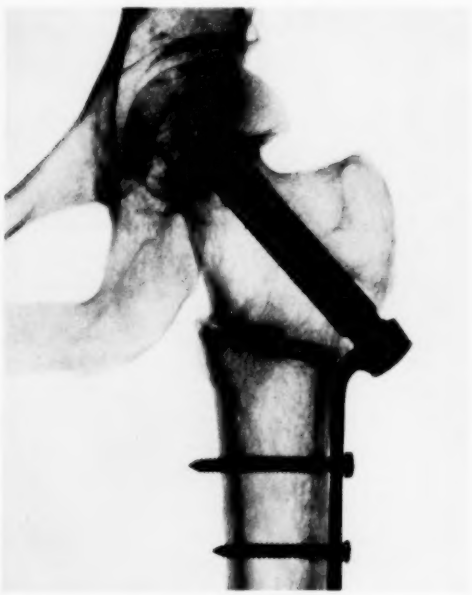

FIG. 3

FIG. 4

Case 7.—Radiographs nine months after operation for recent fracture.

head turned into varus, and the nail cut out. In the remaining eight patients bony union occurred at both fracture and osteotomy sites with good function and no measurable alteration in the length of the limb. The fracture-shaft angle after osteotomy varied according to the size of the wedge removed; in the eight satisfactory cases the angle was increased to 55 degrees or more. The results were gratifying and showed considerable improvement over those previously obtained.

This investigation has not included a study of the incidence of avascular necrosis of the femoral head, but it will be seen from radiographs that if necrosis should occur the anatomy is such that further reconstructive surgery can be carried out.

SUMMARY

1. Ten cases are reported of subcapital fractures of the femoral neck with low fracture-shaft angles treated by wedge osteotomy and fixation by nail-plate.

TABLE II

CLINICAL DETAILS OF TEN SUBCAPITAL FRACTURES TREATED BY OSTEOTOMY AND NAIL-PLATE FIXATION

Case number	Initial fracture-shaft angle (degrees)	Angle after osteotomy (degrees)	Increase in angle (degrees)	Result	Remarks
1	27	70	43	Bony union	Fracture ununited four months after primary nailing
2	5	55	50	Bony union	Fracture ununited five months after primary nailing
3	15	80	65	Bony union	Fresh fractures
4	20	50	30	Poor	
5	20	55	35	Died	
6	30	60	30	Bony union	
7	25	55	30	Bony union	
8	30	70	40	Bony union	
9	30	75	45	Bony union	
10	25	73	48	Bony union	

2. A simple method of osteotomy to increase the fracture shaft angle is described.

3. In eight fresh fractures bony union was obtained when nailing was followed by immediate osteotomy.

4. The alteration of the bony anatomy does not prejudice further reconstructive surgery should it become necessary.

I wish to acknowledge with thanks the help of Mr J. Rentrew White and Mr H. W. Fitzgerald, of Dunedin Hospital, New Zealand.

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A SIGN OF SCIATIC NERVE ROOT PRESSURE

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Although an extruded intervertebral disc has become recognised as the most common cause of sciatica, there are still pitfalls in the diagnosis. The concept that there might be a mechanical cause of sciatica as opposed to the inflammatory theory was first postulated in 1911, when Goldthwait ascribed the onset of paraplegia during manipulation, in a patient with "sacro-iliac subluxation," to a displaced intervertebral disc. Middleton and Teacher (1911) recognised an extrusion of a nucleus pulposus as being the cause of paraplegia at necropsy on a patient who had been merely lifting a heavy steel plate. They tried to reproduce extrusion of the nucleus on cadavers by exerting compression on a flexed spine. But it was not until 1934 that Mixter and Barr put the concept of sciatica on a firm mechanical basis by their demonstration that an extruded intervertebral disc is the common cause.

Anatomical attachments of the lumbar and sacral nerves—O'Connell (1943) has emphasised that compression of the lumbar nerve roots between the protruded disc and the ligamentum flavum is uncommon because the nerve roots act as guy-ropes holding the dura forwards, so that there is a wide space posteriorly in the lumbar vertebral canal. The nerve is tethered proximally through the continuity of the dura mater with the fibrous tissue in the nerve root; by virtue of this attachment the nerve shifts cephalad when the sub-arachnoid space is distended by jugular compression and when the attachment of the dura mater to the foramen magnum is moved during flexion of the neck. Distally, the nerve fibres are attached to muscle and skin. Thus a sciatic nerve root is fixed at each end (Fig. 5), and though it is free to glide between its attachments it has no freedom of movement forwards.

The effect of straight leg raising—When straight leg raising reproduces sciatic pain the sign is regarded as evidence of root pressure produced by a protruded disc. The exact mechanical basis of the test has been the subject of controversy. This problem has been investigated by the author in experiments on a cadaver which are described in a later paragraph.

THE POSTERIOR TIBIAL NERVE SIGN

In 1946, at an operation for suture of a sciatic nerve undertaken by Dr James E. Bateman, it was observed that pressure upon the posterior tibial nerve where it bridged the popliteal space increased the strain on the suture line. It was suggested that this observation might form the basis of a useful clinical test in the investigation of patients with sciatica. The test is performed as follows: straight leg raising (that is, passive flexion of the hip with the knee fully extended) is carried out first on the affected side and then on the sound side (Fig. 1). When the limb has been raised to the point when pain is produced, the knee is flexed about 20 degrees and the limb is then raised further, to a point just short of that which again causes pain (Fig. 2). Firm pressure applied to the middle of the popliteal space, over the posterior tibial nerve, causes sharp pain in the lower lumbar region or in the affected buttock. In the sound limb the test either causes no pain at all or causes pain in the lumbar region or in the opposite buttock. The slight local tenderness of a normal posterior tibial nerve is overshadowed by the gluteal pain when the sign is positive.

AN EXPERIMENTAL STUDY

To demonstrate the mechanical basis of the straight leg raising test and the posterior tibial nerve test experiments were made on a fresh cadaver. The psoas major muscle was

FIG. 1

FIG. 2

The posterior tibial nerve test. The straight leg is raised to the pain producing angle (Fig. 1). The knee is then flexed about 20 degrees and digital pressure is applied sharply to middle of the popliteal space where the posterior tibial nerve can frequently be palpated (Fig. 2)

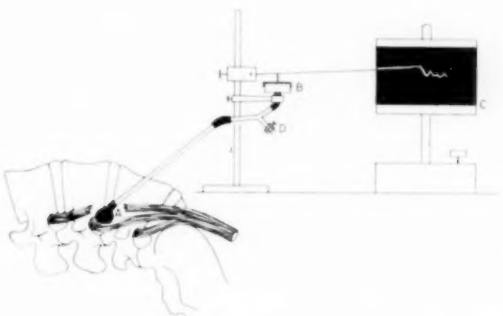

FIG. 3

Apparatus for recording pressure changes in the experiments described in the text.

FIG. 4

Tracing of a smoked-drum record of the posterior tibial nerve sign. A is the increase in tension on straight leg raising. B is the decrease in tension on flexing the knee about 30 degrees. C represents the changes in tension caused by alternately pressing and releasing the posterior tibial nerve in the popliteal space. D is the point at which the knee is extended to usual straight leg raising position.

removed and the fourth and fifth lumbar nerve roots were exposed. The intervertebral foramen was enlarged and the fourth lumbar root was displaced slightly by a rubber bulb inserted anteriorly in the usual position of an extruded disc. The bulb was attached through water-filled tubing with a tambour. Changes of pressure within the bulb were recorded on a smoked drum through a lever activated by the tambour (Fig. 3). Changes in the tension of the roots were noted during straight leg raising and during the posterior tibial nerve test (Fig. 4). Straight leg raising increased the tension (A in tracing), which was immediately lowered by flexing the knee about 20 degrees (B in tracing). Pressure on the posterior tibial nerve increased the tension almost as much as the initial straight leg raising (C in tracing represents repeated application of pressure). The mechanical basis of the tests, as deduced from these experiments, is illustrated in Figures 5 and 6.

FIG. 5

Mechanical basis of the posterior tibial nerve test. The attachment of the sciatic nerve distally to the skin and muscles and proximally to the dural sheath is indicated. The intervening part is free to slide. Pressure on the nerve in the popliteal space increases the tension on the nerve when the hip is flexed sufficiently to take up the slack.

FIG. 6

The sciatic nerve has an angular course from the intervertebral disc forwards to the anterior surface of lateral mass of the sacrum and then back to the posterior surface of the acetabulum. This explains why small disc extrusions may produce marked pressure effects.

DISCUSSION

Mixter and Barr (1934), Bradford and Spurling (1941), Charnley (1951) and others have emphasised that the straight leg raising test is the most informative clinical sign in the diagnosis of extruded intervertebral discs and in assessing progress after non-operative treatment. The posterior tibial nerve sign has been found to be a useful refinement of the usual test. It has been employed to distinguish between pain referred down the leg from a fibrositic nodule (a rare but definite entity) and true sciatic pain from nerve root pressure. Patterns of referred pain for each sclerotome were observed consistently by Kellgren (1948) when he injected the interspinous spaces with hypertonic saline. These pain patterns of the lower lumbar spaces simulate the patterns of pain from nerve root pressure very closely. Lewis

(1942) believed that referred pain from the deep structures was due to localisation to the skin by the cerebrum of all impulses from the particular nerve fibre. This concept of referred pain suggests how a lesion of the connective tissue, muscle, or even of bone, may produce pain of the same distribution as that from nerve root pressure. The posterior tibial nerve sign helps to eliminate the false positive straight leg raising test that may sometimes be observed in cases of referred pain unassociated with nerve root pressure. Unless the lesion is directly related to the nerve root, the posterior tibial nerve sign is negative. The test may be positive however when there is pressure upon the nerve in the spine or pelvis, whatever the cause of the pressure.

It may be argued that dorsiflexion of the ankle at the limit of straight leg raising will produce the same effect as posterior tibial nerve compression. But a brisk movement of the ankle is usually accompanied by movement of the hip or of the back which can be misleading. The posterior tibial nerve sign offers a convenient method of moving only the sciatic nerve.

SUMMARY

Experiments have shown that the tension of the sciatic nerve roots is increased when the posterior tibial nerve is pressed upon in the popliteal space. A refinement of the straight leg raising test, based on this observation, is described.

This work was done at the University of Toronto under the stimulation and guidance of Dr. R. I. Harris, to whom I am very grateful.

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UNCOMMON COMPLICATION OF SLIPPING OF THE UPPER FEMORAL EPIPHYSIS

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Although for some time it has been recognised that imperfect results after the reduction of a slipped upper femoral epiphysis may arise from the formation of new bone on the under surface of the neck of the femur, it is thought worth while to record a clear example of the condition where such new bone was removed at operation. It is believed to be the only published record of direct operative attack upon this complication of adolescent coxa vara.

A schoolboy of average build, aged fifteen years, began to complain of weakness and stiffness in the left hip joint, and radiographic examination one month later revealed early slipping of the femoral head. Three days later the boy stumbled when walking, and displacement of the epiphysis was greatly increased (Fig. 1). After one week of balanced traction of 26 lb. on the affected limb the downward but not the backward displacement was reduced; under general anaesthesia reduction was completed by gentle manipulation with traction and medial rotation. A trifin nail was then inserted to fix the head slightly

Fig. 1
Before operation.

Fig. 2
After nailing.

above and behind the normal position (Fig. 2). The patient was kept in bed for six weeks and thereafter he walked with crutches, without weight bearing on the affected side, for six months. Full weight bearing was then permitted. Nine months after the operation, the epiphysial line having closed, the nail was removed. After that, there was persistent abduction deformity, accompanied after two years by sharp attacks of lumbago which so added to the discomfort resulting from altered gait and posture that further intervention became imperative.

Examination—When the boy was standing there was obvious abduction of the left hip joint with tilting of the pelvis and compensatory scoliosis. This abduction was slightly more than 5 degrees in extension and it disappeared with flexion. There were also a 10 degrees fixed

flexion deformity and complete loss of medial rotation. A bony prominence was visible in radiographs at the lower end of the upper femoral epiphysial line, apparently impinging upon the acetabulum, and this was thought to be the cause of the deformity and limitation of movement (Fig. 3).

Operation—The hip joint was exposed by an anterior approach with division of the straight head of rectus femoris. The capsule was incised longitudinally to expose the bony boss which had been brought into the bottom of the wound by abduction and lateral rotation of the femur. It was situated at the lowest part of the neck, immediately distal to the margin of the articular cartilage; smoothly covered with periosteum, it had the appearance of a

FIG. 3

FIG. 4

Figure 3—Two and a half years after nailing. Note the infero-medial bony projection. Figure 4—Drawing of the bony projection with (inset) a photograph of the bone excised.

simple exostosis. It was removed in one piece (Fig. 4). One month later, adduction movement had increased to 20 degrees and medial rotation to 30 degrees; all other movements were full. Five months later there was only slight limitation of medial rotation. Recently, three years after the operation, the boy has been accepted for military service in the highest medical category.

DISCUSSION

It is suggested that the new bone formation on the inferior aspect of the femoral neck in this case was due to organisation of callus formed in the angle between the head and neck of the femur in the stage of chronic slipping, the mass being left behind on the prominence of the neck when the head was reduced upwards. Howorth (1949) noted that this callus is formed rapidly; and both Key (1948) and Ferguson and Howorth (1931) advised its removal in open reduction of the displaced epiphysis. Several other workers have described the formation of callus (Key 1926, Wardle 1933, McMurray 1938, Green 1945, Kleinberg 1946) but have not found it to cause symptoms; but MacAusland (1935) mentioned one case in which "a small projection of bone restricts motion, making it impossible for the patient to cross his legs."

Whitman (1909) and Heyman (1949) both described removal of bone from the upper anterior part of the neck by which to increase the range of movement after slipping had ceased, but their cases all had great displacement and the bone removed was part of the normal neck abnormally displaced. The bony boss in the case now reported was perhaps

increased by the over-correction upwards of the displacement, but that alone does not seem to have been sufficient to account for the exostosis that developed or for the striking deformity that it produced.

I wish to thank Mr B. H. Burns for permission to describe this case, which was under his care, and for his most generous advice and encouragement.

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A RECONSIDERATION OF CUP ARTHROPLASTY OF THE HIP

With a Precise Method of Concentric Arthroplasty

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The contribution made to hip surgery by Smith-Petersen's (1939) introduction of cup arthroplasty is universally acknowledged. A successful arthroplasty, with abolition of pain and preservation of useful movement, is gratifying to the surgeon and a merciful relief to the patient. Yet the more results one sees, the more does it become clear that in a disconcerting proportion of cases the patient continues to have pain in the hip or thigh after the conventional cup arthroplasty. Because of this and other disadvantages—such as the long period of post-operative rehabilitation that is necessary—many surgeons have abandoned cup arthroplasty in favour of replacement arthroplasty (Judet and Judet 1950) which has given promising short-term results and which demands a relatively short period of rehabilitation.

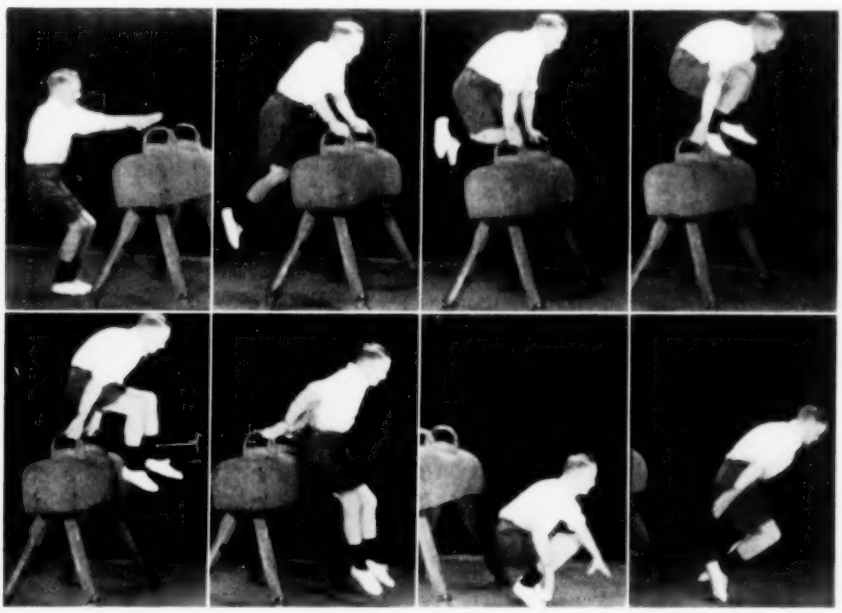

FIG. 1

Film cuts to show the excellent function that follows a successful cup arthroplasty. The patient, at fifty-three, has no difficulty in clearing the "horse" with a running jump, bringing his feet forwards either within or outside the hand-grips. His hip does not limit the distance that he can walk or run. He is no longer conscious of any disability. Can a result such as this be achieved and maintained after prosthetic replacement arthroplasty?

Nevertheless most surgeons will agree that a successful cup arthroplasty is as good as, and probably better than, prosthetic replacement of the femoral head; for the function of the hip may be so nearly normal that the patient is no longer conscious of any disability (Fig. 1). Moreover, once a good result has been secured from cup arthroplasty there is every prospect that it will continue to be good for an indefinite period; in fact the function of the

new joint will usually improve as the years go by. There is movement at both sides of the cup and each movable surface is protected by a smooth lining which ultimately takes on the characteristics of articular cartilage (Smith-Petersen 1948). There is nothing to go wrong; nothing to loosen. On the other hand there is, so far, no indication what will be the long-term results of prosthetic replacement arthroplasty. It may indeed be that the early satisfactory results will be maintained indefinitely. But it may happen that in some cases the prosthesis will loosen on the femur and that further symptoms will eventually arise, whether it be after five, ten or even twenty years. A further disadvantage of replacement arthroplasty is that, if it turns out to be unsuccessful, alternative measures, such as arthrodesis, are rendered difficult by loss of the femoral head.

For these reasons we should not abandon cup arthroplasty. On the contrary, we should consider afresh the causes of persistent pain after unsuccessful cup arthroplasty, and strive to eliminate them. If, as the writer believes, the operation can be made more reliable, it should continue to find a useful place alongside the newer method of prosthetic replacement arthroplasty. In particular, cup arthroplasty would be indicated in relatively young and active patients (provided the local anatomical conditions were favourable) whereas prosthetic replacement would find its main application in the aged or decrepit.

CAUSES OF PAIN AFTER CONVENTIONAL CUP ARTHROPLASTY

Experience suggests that pain persisting after the conventional operation is not directly correlated with any known variation in the extent of the operation or with the omission of any detail of technique. For instance, the assertion that relief of pain is dependent upon thorough excision of the joint capsule cannot be substantiated: in most of the writer's cases the capsule has been preserved and yet pain has been relieved. It seems more likely that pain after operation results from some unpredictable imperfection in the mechanics of the new joint. That the joint is indeed crude and potentially ill-fitting is clear from the fact that no reliable criteria for selecting the best size of cup have ever been given. The fitting of the cup has always been largely a matter of guesswork and therefore a possible source of error.

Mechanical imperfections of the conventional cup arthroplasty—The usual type of arthroplasty, with cups of the accepted Smith-Petersen pattern, is mechanically inefficient in several respects.

Excessive clearance between the moving parts—When the joint surfaces have been adequately shaped and smoothed the femoral head is usually much smaller than the acetabulum, and the disparity is not fully compensated by interposition of the thin walls of the cup (Fig. 2). Therefore either the head fits loosely in the cup or the cup fits loosely in the acetabulum. A loose fit gives the following disadvantages. 1) There is a tendency to instability with risk of dislocation. 2) The centre of the femoral head may not remain in a constant position within the acetabular cavity in all positions of the joint (Fig. 3). In other words movement may be eccentric, not concentric. 3) The pressure of weight-bearing is not distributed over a wide area of the joint surfaces as in a normal hip, but is concentrated upon the small area of contact (Figs. 2 and 3).

Displacement of the axis of movement—The natural attrition of the articular cartilage and the operative trimming and shaping of the joint surfaces combine to produce a loss of depth, which is restored only partly by the interposition of the thin-walled cup. Consequently the head of the femur is displaced upwards and the abductor muscles are shortened (Fig. 2).

The shape of the cup—The straight sides and everted rim of the cup hinder its free concentric movement in the acetabulum; rotation about its central axis is the only movement that can occur concentrically.

Observations at re-exploration for pain after cup arthroplasty—Three unfavourable features have been observed. The commonest is eccentric movement: when the joint is moved through its full range the axis of movement of the femoral head does not remain

constant in relation to the acetabulum. Sometimes, at a certain point in the movement the femoral head will suddenly slip into another part of the cup. This observation bears out what was suspected from mechanical considerations. The second unfavourable feature that has been found is local exposure of bone, usually on the femoral head at the point of weight-bearing. The exposed bone, hard and yellow, contrasts strikingly with the smooth lining membrane that covers the rest of the articular surface and which, in cases of painless arthroplasty, has been observed to cover the whole articular surface (Gibson and Williams

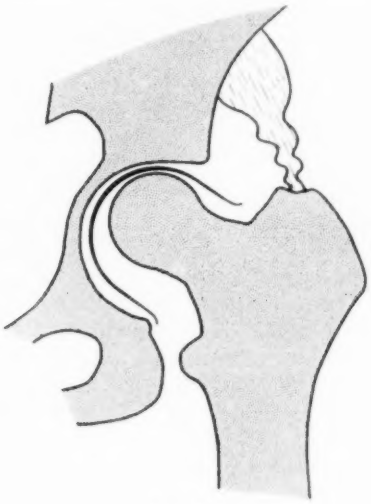

FIG. 2

Diagram showing the mechanical deficiencies of the conventional cup arthroplasty—namely, excessively loose fit, upward displacement of the femur, and incongruous shape of the cup. Note that the pressure of weight-bearing is concentrated on a small area of the femoral head (see text).

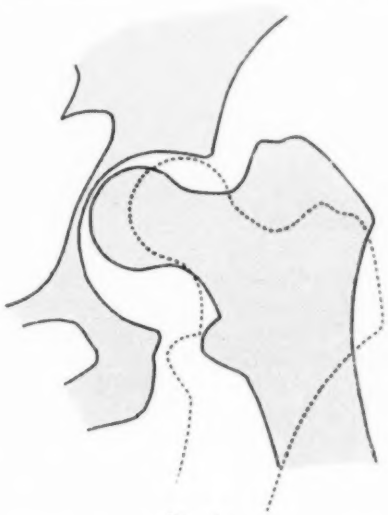

FIG. 3

To show how a loose fit favours eccentric movement. There is nothing to retain the axis of movement of the femoral head in a constant relationship to the acetabulum in all positions of the joint. Here, for example, the axis has moved outwards between abduction (continuous line) and adduction (broken line). (Cup omitted for clarity.)

1951). The third feature, seen especially when the head and neck of the femur are short, is abutment of the rim of the cup against the soft-tissue coverings of the bone in the trochanteric region.

Interpretation of the findings. Eccentric movement due to ill-fitting joint surfaces must predispose to recurrent strains of the capsular ligaments (whether natural or regenerated). The action of such a joint may be likened in principle to that of a cam, a device used widely in engineering when powerful tension is required. Though eccentric movement is probably the predominant cause of strain, inefficiency of the abductors, from upward displacement of the femur, may be a contributory factor because it throws the stress of checking adduction upon the capsular ligaments. Recurrent strains of the capsule cause sharp local pain on movement. In addition, the mechanical irritation sets up an inflammatory reaction with local congestion of the tissues and consequent aching which may persist even at rest.

The cause and the significance of local areas of exposed bone at the articular surfaces are debatable. When there is marked inequality between the moving parts (femur, cup, acetabulum) the pressure of weight-bearing is concentrated in a very small area (Fig. 2) and it is reasonable to suppose that excessive local pressure may prevent the development of a stable protective membrane upon the bone. When a deficiency in the protective membrane is associated with pain the strong possibility that the two are correlated must be accepted.

The significance of impingement of the rim of the cup at the base of the femoral neck is also uncertain. It is probably less important as a cause of pain than the other factors mentioned.

Conclusions – It is believed that pain after the standard cup arthroplasty arises from three causes, in the following order of importance. 1) Recurrent strains of the capsular ligaments, permitted by eccentric movement of the femoral head in the acetabulum and aggravated by inefficiency of the abductor muscles. 2) Local exposure of bone in the weight-bearing area of the joint, favoured by disparity in size between the moving parts and consequent concentration of pressure in a small area. 3) Impingement of the rim of the cup at the base of the femoral neck, when the head and neck are short.

A PRECISE METHOD OF CONCENTRIC ARTHROPLASTY

Believing that pain after cup arthroplasty often arises from the mechanical imperfections described, the writer has developed during the last three years a modified technique which aims 1) to ensure concentric movement of the femoral head within the acetabular cavity; 2) to allow only a small but a uniform clearance between the moving parts; and 3) to retain the axial point of the femoral head as near to its normal position as possible. The principal modifications are in the design of the cup and in the careful shaping of the joint surfaces to exact dimensions (Fig. 4). The cup forms approximately two-thirds of a sphere (Fig. 5). Its walls are a quarter of an inch thick – sufficient to compensate for loss of bone and cartilage and thereby to minimise upward displacement of the femoral head. The inside of the cup is machined to a spherical contour. When the femoral head is within the cup there is a clearance between their surfaces of one-sixteenth of an inch all round; this is sufficient to allow the formation of a smooth surface membrane, but not enough to impair stability. A similar clearance is allowed between the cup and the acetabulum. Only one size of cup has been used, but a second size is available for very small hips. Since the new joint is made to exact measurements, difficulty in selecting the correct size of cup is eliminated. The cups used so far have been of acrylic resin, but cups of inert metal have recently been introduced.

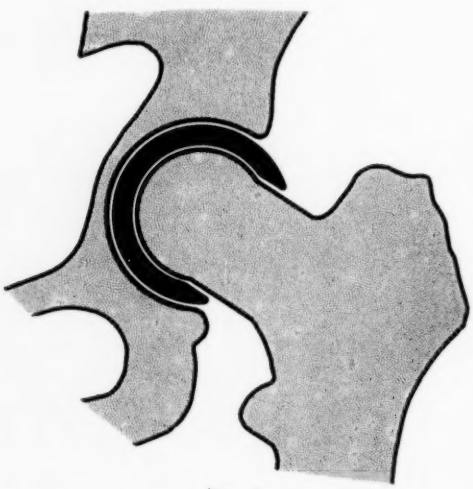

FIG. 4

Scale drawing of concentric arthroplasty. Note the snug fit of the moving parts, which ensures concentric movement and widely distributed weight-bearing contact. The clearance is sufficient to allow the formation of lining membranes upon the acetabular and femoral surfaces. The thickness of the cup compensates for the loss of bone and cartilage and thus minimises upward displacement of the femur.

Anatomical requirements – The head and neck of the femur should be of good length. The bony structure of the femoral head and of the acetabular region of the ilium should be sound, and the joint must be free from active infection. Unless these conditions are satisfied some other procedure would usually be preferred to cup arthroplasty.

Technique of operation – The operation follows the general lines of the Smith-Petersen procedure. The incision will depend upon individual preference; the writer prefers a postero-lateral approach, which gives more direct access to the acetabulum than do the anterior incisions. After dislocation of the hip the diameter of the femoral head is measured with a caliper: if it is greater

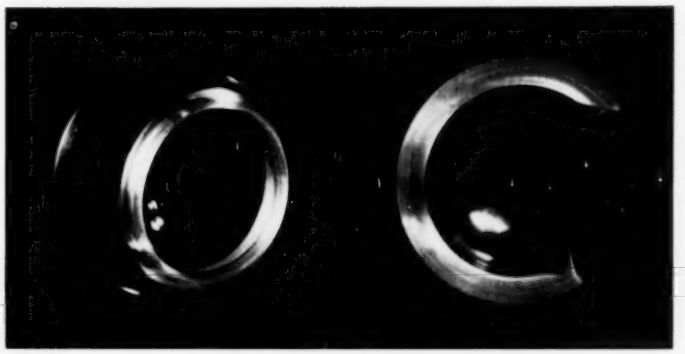

FIG. 5

The modified cup shown entire and sectioned

than $1\frac{5}{8}$ inches the larger size of cup is the one to use. This will almost always be the case, except in diminutive women (arthroplasty has not been undertaken in children). The acetabulum is enlarged concentrically by suitable gouges, all diseased and sclerotic bone being removed. It is important that in removing bone the cavity be kept spherical. Enlargement proceeds until the brace-operated ball reamer ($2\frac{3}{16}$ inches in diameter at equator, or $1\frac{7}{8}$ inches if the smaller cup is to be used) will just fit into the cavity. The reamer is used only for the final smoothing, not to form the cavity. This point should be emphasised. The reamer removes very little bone, and if it is used before the cavity has been made large enough it will not cut its way to the full depth of the acetabulum, even though considerable time and effort be expended. In that event the cavity will not be spherical but will be shaped as shown in section in Figure 6, and in consequence the cup will not fit deeply enough. When the acetabulum has been fashioned the femoral head is shaped with a chisel and finally smoothed with a reamer to a spherical contour, the diameter being $1\frac{9}{16}$ inches ($1\frac{1}{4}$ inches if the smaller cup is used). The neck is shaped to a diameter a little smaller than that of the head (Fig. 4). Care must be taken to ensure that the head is not cut too small: the narrowed mouth of the cup should push over the head only with considerable force (once in position, however, the cup will rotate freely on the head). When the dislocation has been reduced the joint is remarkably stable and movements are concentric. When this has been confirmed the capsule is repaired and the wound closed. The origins of the adductor muscles are divided subcutaneously as a routine, either before or at the end of the operation.

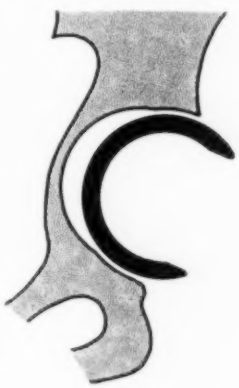

FIG. 6

Diagram showing the result of attempting to ream the acetabular cavity before it has been enlarged sufficiently by gouges. The smoothing reamer cuts away very little bone, and if used prematurely it will not cut its way to the full depth of the socket.

Post-operative treatment The joint is so stable that dislocation is not to be feared and the details of the early post-operative treatment are relatively unimportant. The writer prefers to rest the joint in a comfortable position such as that afforded by Russell traction, encouraging static muscle contractions but deferring joint movements until two or three weeks after the operation, when the soft tissues may be presumed to be healed. Thereafter, active and assisted hip movements are encouraged, with particular attention to the redevelopment of the extensor and abductor muscles. Walking is begun after six or seven weeks, according to progress.

Comment It must be emphasised that meticulous care is necessary in shaping the acetabulum and the femoral head to the

FIG. 7

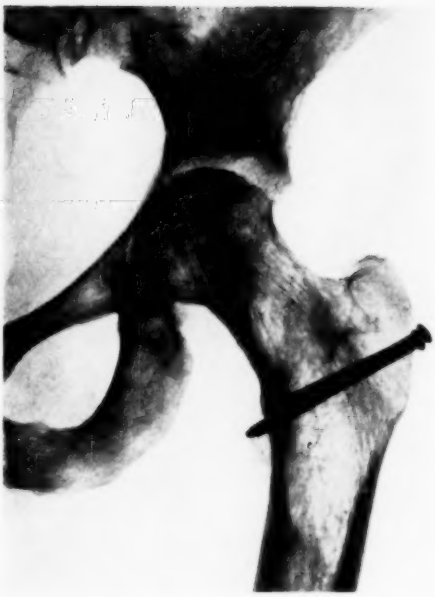

FIG. 8

CASE 3.—Woman aged fifty-five, with rheumatoid arthritis affecting both hips, had been bedridden for a year. Figure 7.—Left hip, before operation. Figure 8.—One year after concentric arthroplasty. The right hip was similar. Note that Shenton's line is almost unbroken, which suggests that the axis of movement is approximately in the normal position.

FIG. 9

FIG. 10

CASE 5.—Woman aged SIXTY-SEVEN. Previous cup arthroplasty had been done unsuccessfully for painful osteoarthritis. Figure 9.—Before re-operation. Figure 10.—SIX months after concentric cup arthroplasty.

correct size and shape. The whole object of the method is defeated if the operation is performed hastily without regard to the details of technique.

CLINICAL ASSESSMENT

So far this modified technique of arthroplasty has been carried out in only twenty-seven cases, and it is therefore too early to assess the results accurately. It can be said

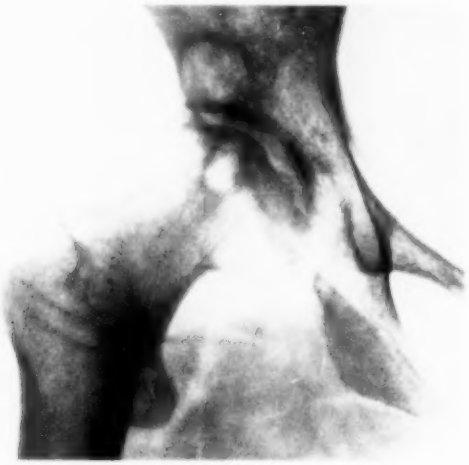

FIG. 11

FIG. 12

Case 18. Woman aged thirty-nine. Old congenital dislocation of hip treated in early childhood. Pain had become disabling. Figure 11.—Before arthroplasty. Figure 12.—Nine months after concentric cup arthroplasty. Note the concentric outlines of the joint surfaces.

with confidence, however, that patients have done better after this operation than did the writer's patients after the conventional arthroplasty. Rehabilitation after operation proceeds more rapidly than after the conventional cup arthroplasty, probably because of the greater stability of the new joint, by virtue of which the patient may often regain the power of straight leg raising within three weeks of operation and may walk with fair confidence

TABLE I

CLINICAL DETAILS IN TWENTY-FOUR CASES OF CONCENTRIC CUP ARTHROPLASTY

Case No.	Sex	Age (years)	Side affected	Primary condition	Clinical state before operation	Post-operative treatment		Result				Remarks
						Type of splintage	Time weight-bearing begun	Duration of follow-up	Significant pain	Movement	Function	
1	M	55	Left	Protrusio acetabuli	Severe pain. Unable to work. Could walk ½ mile with sticks	Traction in Thomas splint 4 weeks, then free	14 weeks	3 years	None	Flexion 70° Abduction nil	Good. Able to walk 3 miles	Conventional arthroplasty on opposite hip. Moderate pain persisted
2	F	55	Right	Rheumatoid arthritis (bilateral)	Had been bedridden for 1 year, but ability to walk 100 yards with severe pain restored before operation	Abduction by below-knee plasters and cross-bar 7 weeks	12 weeks	2½ years	None	Flexion 40° Abduction 5°	Fair. Limited to ½ mile	Previous unstable arthroplasty right hip. Patient died from stroke 2 years after operations
3			Left			Abduction by below-knee plasters and cross-bar 4 weeks	15 weeks	2½ years	None	Flexion 50° Abduction 30°	Good	
4	F	69	Right	Fracture neck of femur: degenerative arthritis	Confined to house. Severe pain. Fixed flexion-abduction	Traction in Thomas splint 4 weeks	12 weeks	2 years	Severe on walking	Flexion 30°	Poor	Femoral neck fracture not united by bone. Avascular necrosis; collapse of head and separation at old fracture
5	F	67	Left	Osteoarthritis (failed arthroplasty)	Severe pain. Unable to walk. Hip fixed in adduction	Well-leg traction 3 weeks	5 weeks	2 years	Slight occasional	Flexion 45° Abduction 10°	Moderate	Unsuccessful vitallium cup arthroplasty 3 years before. Handicapped by osteoarthritis both knees
6	F	38	Left	Congenital subluxation	Fixed flexion. Very little movement	Traction in Thomas splint 4 weeks	8 weeks	2 years	None	Flexion 50° Abduction 20°	Good. Able to walk 3 miles	Congenital dislocation of other hip
7	F	70	Left	Osteoarthritis	Almost unable to walk. Confined to room	Abduction by below-knee plasters and cross-bar 4 weeks	6 weeks	4 months	None	Flexion 35° Abduction nil	Fair. Handicapped by senility	Acrylic head other side: result similar. Died from heart disease 3 months after discharge from hospital
8	M	67	Right	Osteoarthritis	Disabling pain. Slight fixed adduction	Russell traction 4 weeks	8 weeks	1¾ years	None	Flexion 100° Abduction 30°	Good. Almost normal function	
9	F	45	Left	Congenital dislocation	Disabling pain after walking for 10 minutes	Russell traction 4 weeks	8 weeks	1¾ years	None	Flexion 100° Abduction 30°	Good with stick. Improving. Walks 3 miles, but Trendelenberg positive	Shelf operation both hips 20 years before (at age 25)

10	F	63	Right	Osteoarthritis	Severe pain	Russell traction 4 weeks	8 weeks	1½ years	None	Flexion 90 Abduction 20	Good	
11	F	48	Left	Osteoarthritis	Severe pain Adduction deformity							Disastrous deep wound infection. Head and neck of femur excised for drainage
12	F	77	Right	Osteoarthritis	Confined to chair Unable to walk	Traction in Thomas splint 4 weeks	8 weeks	1½ years	None	Flexion 60 Abduction 10	Moderate	Result satisfactory considering age and state before operation
13	F	78	Right	Senile osteoarthritis	Bedridden Fixed adduction	Well-leg traction 3 weeks	5 weeks	1½ years	None	Flexion 90 Abduction 10	Good	Walks with normal gait without sticks
14	F	69	Right	Osteoarthritis	Fixed adduction Confined to house Pain prevented normal sleep	Abduction by below-knee plasters and cross-bar 2 weeks Russell traction 2 weeks	6 weeks	1¼ years	None	Flexion 110 Abduction 20	Good	Full activity
15	M	68	Left	Senile osteoarthritis (bilateral)	Marked stiffness Limited to 100 yards	Russell traction 4 weeks	8 weeks	1¼ years	None	Flexion 40 Abduction 20	Good	Convalescence complicated by delirium tremens, cardiac oedema and dysuria
16	M	68	Right	Senile osteoarthritis (bilateral)	Marked stiffness Limited to 100 yards	Russell traction 4 weeks	6 weeks	1¼ years	None	Flexion 40 Abduction 15	Good	Convalescence complicated by delirium tremens, cardiac oedema and dysuria
17	M	62	Left	Osteoarthritis	Severe pain forced retirement	Russell traction 4 weeks	7 weeks	1 year	None	Flexion 90 Abduction 15	Good	Fractured neck of femur 4 months after operation. Sound union followed nailing
18	F	39	Right	Old congenital dislocation	Painful "locking"	Russell traction 4 weeks	6½ weeks	1 year	Slight occasional	Flexion 110 Abduction 30	Good	—
19	F	73	Left	Senile osteoarthritis	Fixed adduction Severe pain	Russell traction 4 weeks	6 weeks	10 months	None	Flexion 60 Abduction 5	Good for age	—
20	F	45	Left	Rheumatoid arthritis	Painful hip and polyarthritis Bedridden	Russell traction 4 weeks	6 weeks	8 months	None	Flexion 90 Abduction 30	Good for hip	Patient greatly handicapped by other disabilities
21	F	39	Left	Old Perthes' disease	Severe pain but moderate function	Russell traction 6 weeks	10 weeks	8 months	None	Flexion 110 Abduction 30	Good	Temporary sciatic paralysis after operation
22	F	65	Right	Senile osteoarthritis	Severe pain Fixed adduction	Russell traction 4 weeks	7 weeks	8 months	None	Flexion 80 Abduction 15	Good	Slight setback from strain at 4 months; recovered
23	F	66	Left	Senile osteoarthritis	Severe pain Fixed adduction	Russell traction 4 weeks. Well-leg traction 10 days	10 weeks	7 months	Slight occasional	Flexion 30 Abduction minus 10	Moderate	Patient uncooperative
24	M	40	Left	Osteoarthritis + Old slipped epiphysis	Forced by pain to give up work	Russell traction 4 weeks	6 weeks	6 months	Slight occasional	Flexion 70 Abduction 30	Good	—

after six or seven weeks. In no case has dislocation or subluxation occurred. Clinical details of the twenty-four cases in which the reconstruction was completed more than six months ago are shown in Table I, and illustrative radiographs are reproduced in Figures 7 to 12. In one case the reconstructed joint was ruined by a deep wound infection which occurred despite a rigid aseptic technique; excision of the head and neck of the femur was necessary as a life-saving measure. With one exception the remaining patients are free from pain or virtually so. The unsuccessful case was in a woman with old avascular necrosis after fracture of the neck of the femur, which was erroneously thought to be united by bone. The head collapsed within the cup, and displacement occurred at the site of the original fracture. Such a case would not now be considered suitable for cup arthroplasty.

DISCUSSION

It seems reasonable to suggest that a precisely constructed ball-and-socket joint acting concentrically about the normal axis of hip movement is more likely to give consistently good results than a loosely fitted joint that may move eccentrically and about a displaced axis. This supposition is borne out by the writer's present experience of the concentric cup arthroplasty described here. Reconstructive operations upon the hip are in a phase of rapid evolution, and it is not suggested that the method described will represent more than an intermediate stage in the evolution of cup arthroplasty. It seems that it may be an improvement on the older method, but no doubt there will be room for future development, perhaps from further modification in the design of the cup, or from other refinements of technique. The main purpose in presenting this paper has been to stimulate further thought and research towards the perfection of the technique of cup arthroplasty, the fundamental principle of which appears to be sounder than that of prosthetic replacement arthroplasty when prolonged service from the reconstructed joint is demanded.

SUMMARY

1. The unreliable results of the conventional cup arthroplasty are attributed to mechanical imperfections in the reconstructed joint.

2. If its reliability can be improved, there will remain a place for cup arthroplasty, which, in relatively young and active patients, offers advantages over prosthetic replacement arthroplasty.

3. A technique of concentric cup arthroplasty is described. The new joint is shaped with precision to exact dimensions and lined with a cup designed to ensure stability, concentric movement and a uniform clearance between the moving parts.

4. The results so far are encouraging and justify continued clinical trial.

The cups are made by Messrs Willen Bros. Ltd., 44 New Cavendish Street, London, W. 1, whose courteous cooperation I acknowledge gratefully. I am indebted to Dr Cardew, of the Photographic Department of St Mary's Hospital Medical School, for the photographs.

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SYNOVECTOMY AND CURETTAGE IN THE TREATMENT OF TUBERCULOSIS OF JOINTS

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From Black Notley Hospital

Girdlestone (1940) wrote that "during his time in the wards of a London hospital, first as a student and then as a house surgeon, Pott's disease and hip disease had meant deformity, septic complications and the slow miserable process of lardaceous disease. In contrast to this, the work of Sir Robert Jones in open-air hospitals in Shropshire and Heswall seemed miraculous. The children with hips, spines and knees looked perfectly well." These words illustrate a principle which is as true to-day as when they were written. They paint a picture of "old, unhappy, far-off things and battles long ago." With the advantages that antibiotics offer to the modern surgeon it is important that the old teaching should not be forgotten. The results described in this paper would not have been possible except in an open-air country hospital where constitutional treatment is carried out carefully.

The value of constitutional treatment alone, though great, was limited. Prolonged splintage was necessary which, in the child, stunted physical development; miliary tuberculosis and meningitis or septic complications might develop. Even after healing of the disease a major operation might be required to stabilise the joint and function was lost. There was a substantial late mortality from associated tuberculous lesions. For example, Harris and Coulthard (1942) followed up 296 patients treated for skeletal tuberculosis for periods varying from one to ten years and found that eighty-five had died. Approximately half of these deaths were from miliary dissemination or sepsis, and most others from associated tuberculous lesions. The main problems therefore, before the introduction of antibiotics, were to reduce the mortality from sepsis, miliary tuberculosis and associated lesions, and to save joint function. The introduction of antibiotics might have been expected to reduce the incidence of sepsis and miliary tuberculosis, and this, in fact, is what has happened at Black Notley, in spite of the adoption of open operations into tuberculous joints which are to be described. The effect of antibiotics on associated lesions has yet to be assessed but its effect appears to be less certain than on the other complications. Nevertheless the adoption of operations on tuberculous tissues, by which a possible antigenic effect may be produced from the drainage of tuberculous material into body tissues, may be of value in reducing the mortality arising from associated lesions. Even before the introduction of antibiotics, results had been published of a series of patients with associated lesions who had been treated by operations into tuberculous tissues (Wilkinson 1946). These results were compared with those of a similar series of patients with associated lesions upon whom no operation had been performed into tuberculous tissue. The late mortality in patients operated upon, with more severe disease which in those days made operation more justifiable, was 7 per cent. In the group of patients in whom no operation was performed the late mortality was 16 per cent.

The main object of operations on tuberculous bones or joints is to heal the local lesion. The purpose of this paper is to describe how far such operations have been successful, when combined with constitutional treatment and antibiotic therapy, in preserving joint function and reducing the time required for treatment. Preliminary remarks on the pathology of skeletal tuberculosis are necessary. The tuberculous infection, bacillaemic in origin, falls most heavily on parts of the joint where there are reticulo-endothelial cells capable of entrapping the bacilli: these reticulo-endothelial cells are found at the ends of long bones and in synovial membrane (Fraser 1935, Mercer 1943, Boyd 1942, Soeur 1949). There is

also free vascular communication between the synovial membrane, capsule and epiphyses (Davies 1946). Thus, usually, there is concomitant infection of synovial membrane and the ends of the long bones—an observation emphasised by Allison and Ghormley (1931) and by

FIG. 1

Radiograph of a child with tuberculosis of the left hip. Strict constitutional treatment was enforced but it was not supplemented by streptomycin or operation. Subsequent radiographs (Figs. 2 and 3) show the progressive development of ischaemic necrosis in the femoral neck with destruction of the joint.

FIG. 2

Same case as Figure 1, two months later.

FIG. 3

Same case as Figure 1, eight months later.

Mortens (1948). At the periphery of the joint, where the synovial membrane is reflected from the cartilage, is the "circulus vasculosus" of Hunter, of which the arteries are end-arteries in the sense that they do not form anastomoses. Local endarteritis is one of the main

features of the pathology of tuberculosis. This may be seen clearly in microscopical sections of tissues from tuberculous joints. To quote Boyd (1929): "A tuberculous obliterating endarteritis followed later by a periarteritis is a very constant feature." It follows, therefore, that ischaemic necrosis is a common and early feature of the pathology of skeletal tuberculosis. Once this has occurred antibiotic drugs can only reach the affected part with difficulty unless the way is opened by curettage of necrotic foci (Figs. 1 to 3).

Not only may ischaemic necrosis occur in bone but the synovial tissues and capsule become engorged and congested. The effect of streptomycin on the histology of synovial tissue is being studied and will be the subject of another paper: the macroscopic changes observed depend on how soon after the start of antibiotic therapy operations have been performed. In patients operated upon after periods up to ninety days the synovial membrane was actively inflamed and microscopy showed tubercles: in those operated upon after ninety days the majority showed tuberculosis microscopically but the changes were more difficult to identify. In patients operated upon late there was thickening of the membrane, which was often adherent to the margins of the articular cartilage, but the inflammatory reaction was much less. In no case was normal synovial membrane found. Key (1925) showed that synovial membrane rapidly regenerates after removal: therefore partial synovectomy, accompanied by antibiotic treatment, affords an opportunity for fresh and healthy synovial tissue to be developed, along with fresh blood vessels which will bring the antibiotic into the diseased area.

The results of partial synovectomy, partial capsulectomy and curettage of necrotic foci in bone appear to be satisfactory; after such operations the tuberculous process appears to be arrested and recalcification occurs; partial synovectomy and capsulectomy alone seem to be beneficial in those patients in whom no major necrotic areas are seen. The results of such operations on the hip, the spine and the knee will be considered briefly. A summary of each patient is appended at the end of the paper and a few illustrative examples are mentioned more fully in the text.

TUBERCULOSIS OF THE SPINE

A follow-up of approximately four years of 131 patients who had been treated at Black Notley for tuberculosis of the spine showed that there was unstable ankylosis in 46·7 per cent of the children and 34·5 per cent of the adults, and that this had occurred oftenest when the disease was in the mid and lower thoracic regions (Wilkinson 1949). Unstable ankylosis is a fruitful source of deformity, reactivation of disease and paraplegia. Girdlestone (1940) found that paraplegia occurred in about 10 per cent of all patients suffering from spinal tuberculosis, and Butler (1935) stated that the thoracic spine was the site affected in 157 out of 186 patients whose records he had examined. The relatively poor prognosis for disease in the mid and lower thoracic spine may be due to the persistence of perispinal abscess or granuloma. Swett, Bennett and Street (1940) advocated evacuation of persistent paravertebral abscess as part of the treatment of tuberculosis of the spine; they reached this conclusion from a study of 350 patients with spinal tuberculosis and found that sound healing seldom occurred in the presence of an abscess. This observation, they maintained, was true whether or not a posterior spinal fusion had been performed. Cleveland and Bosworth (1942) described the incidence and effects of ischaemic necrosis in tuberculosis of the spine, and this has also been referred to by Capener (personal communication).

Twenty-three patients have been discharged after operation for spinal tuberculosis by means of evacuation of the abscess and curettage of granulomatous material. The operation entails costo-transversectomy of one, or preferably two, ribs and transverse processes: it is necessary to remove the transverse processes and rib heads cleanly to ensure a view of the lateral aspects of the vertebral bodies. Two chief groups of patients were selected for operation: those whose disease had recurred after previous constitutional treatment, or for whom operation was performed to accelerate and improve the results of initial treatment; and those

with unstable ankylosis and developing deformity, in whom curettage of the lesion was followed by the insertion of bone chips into the resulting defect.

Results. *Reactivated disease*—Eight patients, readmitted after previous treatment, were

FIG. 4

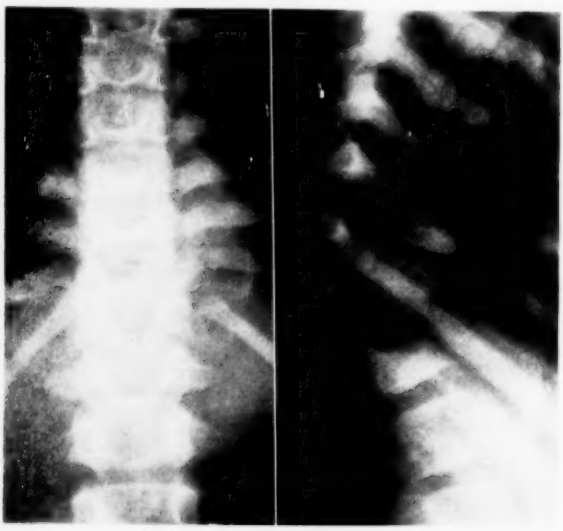

FIG. 5

FIG. 6

FIG. 7

Case 2. Figure 4—Lateral view early in treatment. Figure 5 shows the condition eight months later, before operation. Note extensive destruction of T.10–11 and partial destruction of T.9 and T.12. Figure 6—Eight months after operation; there has been no further destruction of vertebral bodies. Figure 7—Two years and seven months after operation; there has been collapse with commencing bony ankylosis without further vertebral destruction. A posterior graft has been inserted to augment stability.

operated upon. The average duration of treatment was 7·5 months. One, a patient treated when supplies of streptomycin were inadequate, required readmission again later for four months. The remainder were satisfactory. *Active disease in children*—Five children were

operated upon. The average duration of treatment was twenty-six months. Four have gained sound ankylosis; in one the disease has relapsed. *Active disease in adults*—Eight patients were operated upon. The average duration of treatment was eleven and a half months. All patients have gained a sound ankylosis—some have bony ankylosis—and none has relapsed. *Progressive deformity*—Two children have been treated by an attempt at producing strong anterior fusion by means of bone chips inserted into the curetted area of a spine which was quiescent but which was becoming deformed. One appears now to have a sound ankylosis; the other developed further deformity.

CASE REPORTS

Case 2—Girl aged four. Admitted with tuberculosis of the ninth to twelfth thoracic vertebrae with paravertebral abscess. Despite full constitutional treatment the disease progressed; after ten months there was total destruction of the tenth and eleventh vertebral bodies and partial destruction of the ninth and twelfth. Costo-transversectomy was undertaken and pus under considerable tension was released. Since only small quantities of streptomycin were available,

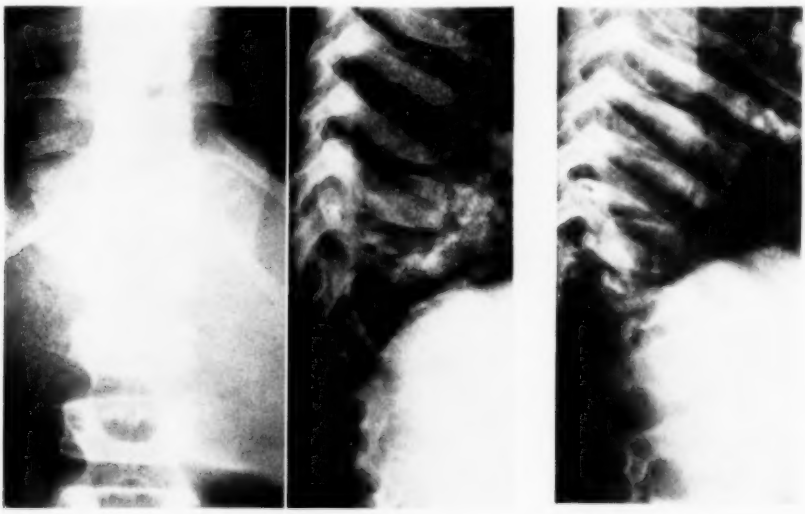

FIG. 8 FIG. 9

Case 3. Figure 8.—Condition two months after admission. There is incomplete destruction of T.11 and 12 and a threat to T.10 and L.1. Operation was performed two months later. Figure 9.—Thirteen months after operation: no vertebral destruction has occurred since operation and there is recalcification of the affected vertebrae.

she was given an operation cover of 200 milligrams daily for six weeks. After operation no further vertebral destruction occurred. She was discharged after twenty-one months' treatment but was readmitted a year later with a small abscess under the scar. A full course of streptomycin was then given and a posterior spinal fusion was performed to augment stability (Figs. 4 to 7).

Case 3—Boy aged six. Admitted with tuberculosis of the eleventh and twelfth thoracic vertebral bodies with paravertebral abscess; miliary tuberculosis of the lungs was also present. After four months, in spite of a full course of streptomycin, the eleventh and twelfth thoracic bodies were almost completely destroyed and the adjacent vertebrae threatened. Costo-transversectomy was undertaken; pus was evacuated and the lesion curetted. No further vertebral destruction took place and the remains of the affected vertebral bodies recalcified. After a period of convalescence posterior spinal fusion was performed to augment stability (Figs. 8 and 9).

Case 7—Man aged twenty-eight. Tuberculosis of the thoracic vertebrae 5–10. He was given a two-months course of streptomycin (one gramme daily). Drainage of abscess and curettage of lesion was then carried out. The patient was discharged fourteen months after admission and progress has been uneventful (Figs. 10 and 11).

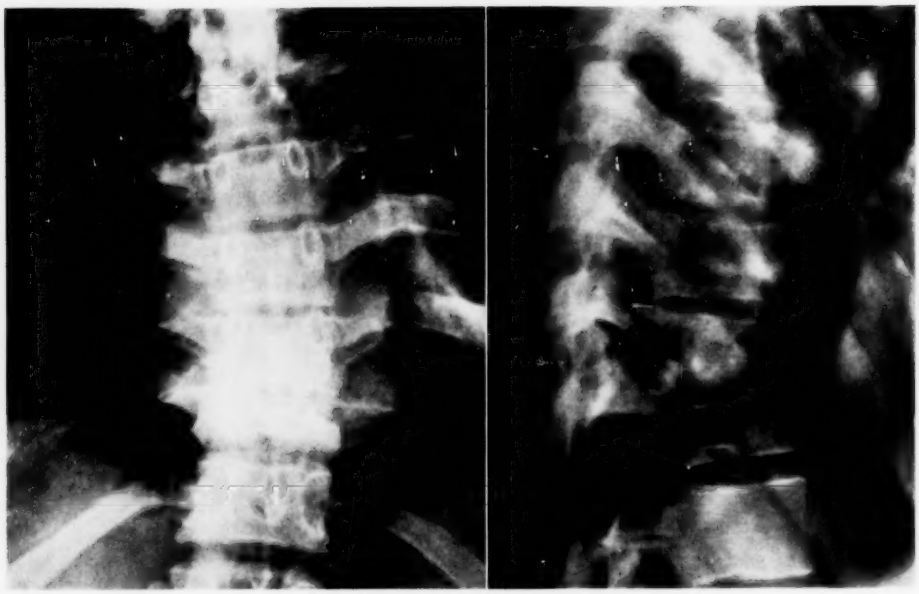

FIG. 10

Case 7.—Condition soon after admission with tuberculosis of T.5–10 with perispinal abscess. Operative drainage of abscess was undertaken seven months after admission.

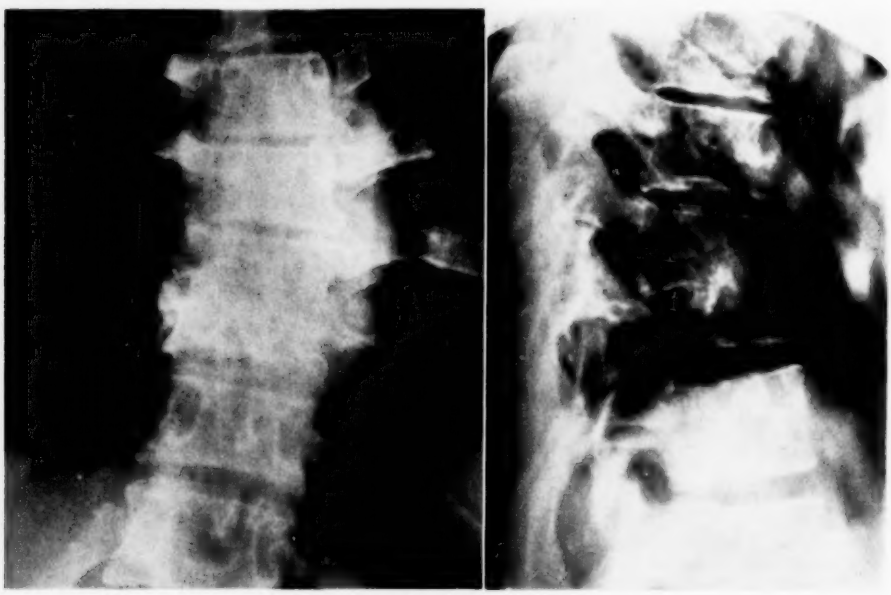

FIG. 11

Case 7.—Six months after operation there is bony ankylosis of T.9–10 and healed disease of T.7–8. The lesion of T.5–6, not seen in this film, had also healed.

FIG. 12

Case 28.—Early radiograph showing ischaemic necrosis in the left femoral neck.

FIG. 13

FIG. 14

Case 28.—Figure 13.—Three months later. Incomplete destruction of the femoral head occurred despite streptomycin therapy. Partial synovectomy and curettage of the ischaemic area were undertaken one week later. Figure 14.—Seven months after operation. The child was walking and had returned home.

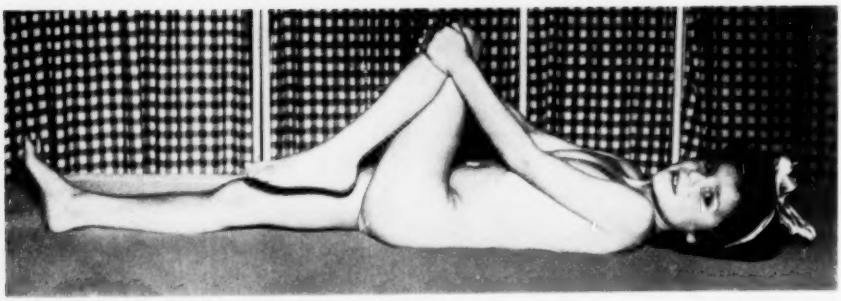

FIG. 15

Case 28.—Showing the range of flexion six months after operation.

TUBERCULOSIS OF THE HIP

Twenty-three children and four adults have been treated by partial synovectomy with or without curettage of necrotic foci. In the adults the cartilage of the femoral head was found to have been destroyed by the disease, possibly because operation was performed too late. The children alone will therefore be considered. The survival of cartilage in tuberculosis of the hip in children is often remarkable, and accords with Phemister's observation (1924) that cartilage survives better in tuberculous than in pyogenic pus. Of the twenty-three children operated upon, treatment was successful in nineteen, in that the disease rapidly became quiescent after operation and a good range of movement was restored; in two it was incompletely successful in that the disease became rapidly quiescent, but function was not restored; in two it failed in that the disease did not become rapidly quiescent and function was not restored. The average duration of treatment in the favourable cases has been ten months, a duration which can probably be reduced in the light of the experience gained. Splints have not been worn by patients discharged. No patient discharged has suffered a relapse.

CASE REPORTS

Case 28.—Girl aged eight. Admitted with acute disease of the left hip which was fixed in flexion and adduction; marked spasm and oedema. Radiographs showed joint changes with an area of ischaemic necrosis in the femoral neck. Streptomycin (0·5 gramme daily) was given but destruction of the femoral head progressed. Partial synovectomy with curettage of the ischaemic area in the neck was performed four and a half months after admission. After operation the bone began to recalcify and no further destruction occurred. The child was walking nine months after admission and was discharged with 90 degrees range of flexion of the hip. Microscopy confirmed tuberculosis (Figs. 12 to 15).

Case 25.—Girl aged six. Active tuberculous synovitis on admission, but 90 degrees flexion movement was present. Partial synovectomy was performed a month after admission; a cavity in the acetabular roof was not curetted. Microscopy of the synovial membrane confirmed tuberculosis. Traction was discarded after five weeks but resumed later for another month owing to return of muscle spasm. Streptomycin (0·25 gramme daily) was administered for ninety days after admission. She was discharged after ten months' treatment with a wide range of movement; the acetabular cavity was healed (Figs. 16 to 18).

Case 45.—Girl aged three. Admitted with gross spasm, oedema and abscess formation of the left hip. Intramuscular streptomycin (0·5 gramme daily) was started but the condition continued to deteriorate. Partial synovectomy was performed one month after admission at a stage when the patient was very ill. The capsule was found to be infiltrated with tuberculous granulation tissue and had perforated; there were three abscesses in relation to the outside of the capsule; the cartilage was intact. Microscopy confirmed tuberculosis. After operation both the child's general condition and local condition of the hip improved. Twelve months after operation the child is still under treatment; there is a 110-degrees range of flexion movement without spasm, and radiographs show that the joint remains intact. Treatment is now being given for a slight degree of subluxation which has complicated the recovery.

Case 26.—Girl aged one year ten months. Admitted with active tuberculosis of the hip; only

15 degrees of flexion movement present. Radiographs showed erosion and excavation of the upper surface of the femoral neck. Treatment by streptomycin had been given before admission. Four months after admission partial synovectomy and curettage of the excavated area in the femoral neck were carried out. Microscopy confirmed tuberculosis. She was discharged after eleven months with a full range of movement.

Case 37.—Girl aged six. Admitted with active tuberculous disease of the right hip. Spasm and oedema present with flexion and adduction deformity. Streptomycin (0·5 gramme daily) started on admission. A small area of ischaemic necrosis was seen in the femoral head. Despite treatment there was progressive destruction of the femoral head. Five months after admission partial

FIG. 16

FIG. 17

Case 25. Figure 16.—Condition of hip on admission. Partial synovectomy was performed one month later. Figure 17.—One year after operation. The patient had been discharged home walking four months before this radiograph was taken.

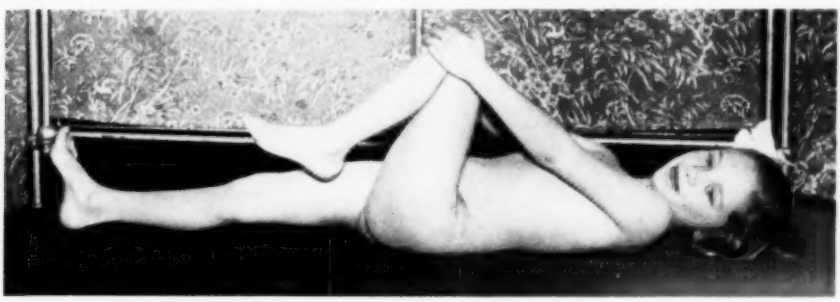

FIG. 18

Case 25.—Showing range of flexion eight months after operation.

synovectomy was carried out, after which no further destruction occurred and recalcification proceeded. Nevertheless joint function was not restored and the child was discharged after a displacement osteotomy had been performed. Microscopy confirmed tuberculosis (Figs. 19 to 22).

TUBERCULOSIS OF THE KNEE

In tuberculosis of the knee destruction of cartilage usually occurs late; even before the introduction of antibiotics recovery with useful movement was sometimes possible in childhood. Mortens (1948) found that, of sixty-two children treated for tuberculosis of the knee, twenty

FIG. 19

FIG. 20

Case 37. Figure 19—Early radiograph showing a small ischaemic area in the femoral head. Figure 20—Three and a half months later. There has been progressive destruction of the femoral head despite streptomycin therapy. Partial synovectomy was carried out soon after this radiograph was taken.

FIG. 21

FIG. 22

Case 37—Six months after operation. No further bone destruction has occurred but the joint was lost. Figure 22—Three months later, after displacement osteotomy.

seven had a useful range of movement ten years afterwards. In adult life recovery with a useful range of movement was rare. The introduction of antibiotics was therefore a signal for an attempt to obtain better functional results by means of a combination of antibiotic treatment and partial synovectomy. The experience gained so far in the treatment of sixteen patients with proven tuberculosis of the knee by these methods has been encouraging.

Results. *Children (fourteen years and under).*—Seven patients were treated. Tubercle bacilli were recovered from the joint in six. Six have overcome the disease and retained a useful range of movement, the flexion range being almost full in three. One child, four years after operation on the knee, has had to be readmitted recently with a fresh lesion in the spine, though there is 120 degrees range of flexion of the knee. It should be noted that she was treated at a time when inadequate amounts of streptomycin were available. Another child failed to recover movement and has required readmission. *Adolescents and adults.*—Nine patients were treated. In seven, tubercle bacilli were recovered from the knee or the diagnosis was confirmed by microscopy; two had multiple associated lesions; and one had a cold abscess before admission. Seven patients regained movement through 90 degrees or more: one has a range of approximately 50 degrees: and one, whose disease had advanced to the stage of considerable cartilage destruction, has had to have an excision of the joint surfaces; at reoperation no evidence of active disease was seen, but unstable and painful ankylosis was present.

CASE REPORTS

Case 49.—Girl aged seven. Admitted with active synovitis, swelling, spasm and 15 degrees fixed flexion deformity. A course of intramuscular streptomycin (0·25 gramme daily) was given, and full constitutional treatment was begun. Four months after admission partial synovectomy was undertaken. The synovial membrane was swollen and red, and pannus was present on the margins of the articular cartilage, though clinically the joint appeared much improved. Active tuberculosis with early reparative changes was reported on microscopical examination. Splints were discarded six weeks after operation and she was discharged walking after eight months' treatment. On re-examination she has almost a full range of movement.

Case 51.—Girl aged eighteen. Admitted with synovitis of the left knee of seven months duration. There was a tuberculous focus in the apex of the left lung, and a tuberculous cold abscess of the chest wall. Tubercle bacilli were recovered from the knee by a guinea-pig inoculation of joint fluid. Intramuscular streptomycin (1·0 gramme daily) was started on admission and partial synovectomy was performed ten weeks later. The synovial membrane was thickened and had become partly adherent to the articular margins of the medial condyle. Microscopically, the synovial membrane was thickened, hypertrophic, fibrous and vascular, but it showed no specific changes. Splints were discarded three weeks after the operation. She was discharged after six months' treatment, when all lesions were quiescent. The range of movement was 90 degrees; it has increased slightly recently. She has since married and had a baby. The knee remains quiescent.

Case 47.—Girl aged nineteen. Admitted with chronic synovitis of the knee and bilateral pulmonary tuberculosis, for which bilateral artificial pneumothoraces had been induced. Her knee had previously been treated for a year in plaster at a sanatorium, and two years before her admission to Black Notley she had been given a course of streptomycin and P.A.S. On admission there was marked synovial thickening; the range of flexion was 90 degrees. Streptomycin (1·0 gramme daily) was given and a month after admission partial synovectomy was undertaken. The synovial membrane was thickened and red and the margins of the articular cartilage were eroded. Microscopically, there were numerous giant-cell systems. She was allowed to walk seven weeks after operation and returned home four months later. At that time there was still increased local warmth over the knee and flexion through 80 degrees was present. On follow-up the knee is quiescent and there is a 90 degrees range of movement.

TABULATED RESULTS IN THE COMBINED SERIES

The results in sixty-two patients treated for tuberculosis of the spine, hip or knee by synovectomy or by curettage of necrotic foci are shown in Table I. All patients were operated upon during the years 1949-52. The designation "successful result" implies in the hip or the knee, restoration of good function with preservation of the joint; and, in the spine, a stable ankylosis, without post-operative vertebral destruction.

TABLE I

Site of disease	Number of patients	Result			Average duration of treatment
		Successful	Incompletely successful	Failure	
Spine					
Reactivated disease	8	7		1	7·5 months
Early active disease					
Children	5	4		1	26 months
Adults	8	8			11·6 months
For progressive deformity	2	1		1	6 months
Hip	23	19	2	2	11·3 months
Knee	16	14		2	9·9 months

SUMMARY

1. Experience in the treatment of tuberculous disease of the spine, hip and knee by combined constitutional, antibiotic and operative measures is described.

2. In patients with tuberculosis of the spine, especially in the thoracic region and when perispinal abscess formation is a prominent feature, the treatment helps to ensure stable ankylosis in the type of case in which it otherwise might not occur.

3. In children with tuberculosis of the hip and in adults and children with tuberculosis of the knee it is usually possible to save the joint and to restore function, provided the joint has not been destroyed before treatment is begun.

I wish to express my thanks to Mr S. L. Higgs for his encouragement in this work, and to acknowledge the help received, in correspondence, from the late Dr P. Swett of Connecticut, U.S.A.

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APPENDIX

SUMMARISED RECORDS OF THE SIXTY-TWO CASES FORMING THE BASIS OF THE PAPER
All patients had typical clinical and radiological evidence of tuberculosis

TUBERCULOSIS OF THE SPINE

Case No.	Sex	Age yrs.	Site of lesion	Amount of streptomycin (grammes)	Nature of operation	Duration of treatment	State of healing on last examination or follow-up	Remarks
1	F	3	T.10-11	3	Evacuation of paravertebral abscess	26 months	Unstable fibrous ankylosis	Relapse and readmission
2	F	4	T.10-11	8·4	Evacuation of paravertebral abscess	23 months	Stable fibrous ankylosis	Readmitted for posterior fusion and further course of streptomycin
3	M	6	T.11-12	135	Evacuation of paravertebral abscess	21 months	Stable fibrous ankylosis	No further vertebral destruction. Posterior spinal fusion later
4	M	28	T.10-12	20	Evacuation abscess and curettage	9 months	Bony ankylosis	Sinus after discharge from hospital healed with further streptomycin
5	M	45	T.7-8-9	6	Curettage of lesion	6 months	Stable fibrous ankylosis	Readmitted 2 years later for 4 months' treatment by streptomycin
6	M	25	T.10-11	11	Curettage of lesion and bone chips	5 months	Partial bony ankylosis	
7	M	28	T.10-11	56	Curettage of lesion	14 months	Partial bony ankylosis	
8	M	24	T.8-10	100	Evacuation of abscess and curettage	10 months	Bony ankylosis	
9	F	39	T.2-4	13	Curettage of lesion and bone chips	8 months	Bony ankylosis	Operation for painful fibrous ankylosis: marked improvement
10	F	49	T.2-4	86	Curettage of lesion and bone chips	16 months	Improved ankylosis	Chronic painful ankylosis markedly improved
11	F	19	T.6-8	64	Curettage of lesion and bone chips	16 months	Improved ankylosis	Operation performed to prevent deformity
12	F	24	T.8-9	90	Curettage of lesion	10 months	Bony ankylosis	
13	F	39	T.8-10	103	Curettage of lesion	7 months	Strong fibrous ankylosis	Painful spine relieved
14	F	10	L.4-5	50	Curettage of lesion and abscess	6 months	Disease healed	
15	F	37	T.8-12	61	Curettage of lesion	11 months	Improved healing	Chronic disease in spine for 11 years before operation
16	M	2	L.1-3	25	Curettage of lesion	3 years	Fibrous ankylosis	
17	F	32	T.9-10	100	Curettage and bone chips	Not discharged	Possible early bony ankylosis	Discharge from hospital pending after 8 months' treatment
18	F	12	T.7-9	6	Curettage and bone chips	5 months	Bony ankylosis	Operation was for fibrous ankylosis and increasing deformity
19	M	30	T.10-11	100	Curettage and bone chips	12 months	Possible early bony ankylosis	Additional (lower lumbar) lesion treated conservatively
20	F	10	T.12 L.1-3	Uncertain	Curettage and bone chips	6 months	Fibrous ankylosis	Failure: deformity increased in spite of operation
21	F	28	T.8-9	90	Curettage of lesion	8 months	Bony ankylosis	Previously treated for disease of T.10-11 which had healed
22	F	13	T.10-12	62	Curettage of lesion	2 years	Bony ankylosis	
23	F	30	T.8-9	90	Curettage of lesion and chips	10 months	Early bony ankylosis	

APPENDIX—*continued*
TUBERCULOSIS OF THE HIP

Case No.	Sex	Age yrs.	Total dose of streptomycin (*grammes*)	Nature of operation	Range of movement: Before operation	Range of movement: Last examination or follow-up	Duration of treatment	Additional evidence of tuberculosis	Remarks
24	M	7	36	Partial synovectomy	80° flexion	Full	9 months	Microscopy positive	
25	F	6	22·5	Partial synovectomy	90° flexion	Full	9 months	Microscopy positive	
26	F	$1\frac{1}{2}$	30	Synovectomy and curettage of focus	120° flexion	Full	9 months	Microscopy positive	
27	F	6	22·5	Partial synovectomy	45°	90° flexion	16 months	Cold abscess incised before admission	
28	F	8	22·5	Synovectomy and curettage	Nil	90° flexion	11 months	Microscopy positive	
29	F	5	63	Partial synovectomy	Nil	70° flexion	8 months	Microscopy positive	
30	F	4	25	Curettage of cavity	Nil	35° flexion	18 months	Progressive disease	No synovectomy: patient relapsed: disease progressed
31	M	7	45	Synovectomy and curettage	Nil	Nil	22 months	Microscopy positive	Progressive disease: failure
32	F	3	25	Partial synovectomy	30° flexion	90° flexion	19 months	Microscopy positive	
33	M	7	—	Curettage of cavity	90°	Full	4 months	T.B. in pus	Acetabular disease with iliac abscess: acetabulum curetted
34	M	4	22·5	Curettage of cavity	Almost full	Full	11 months	Mantoux 1 in 10,000	
35	F	7	39	Partial synovectomy	70° flexion	Full	6 months	Mother and father with phthisis	
36	F	5	50	Partial synovectomy	Nil	90°	14 months	Resolving primary lung disease on admission	
37	F	6	22·5	Synovectomy and curettage	45°	20°	9 months	Microscopical confirmation	Partial success: displacement osteotomy performed
38	M	4	22·5	Synovectomy and curettage	Full	Full	9 months	Mother with phthisis	
39	F	14	45	Synovectomy and curettage	90° flexion	120° flexion	8 months	T.B. in hip abscess	
40	F	7	45	Synovectomy and curettage	90°	Full range	9 months	Microscopy confirmed	
41	F	3	50	Partial synovectomy	90° flexion	Full range	11 months	Mother with phthisis	
42	F	3	22·5	Curettage of cavity	60° flexion	100° flexion	5 months	T.B. in urine	
43	M	6	45	Synovectomy and curettage	25° flexion	Full flexion	10 months	Microscopy confirmed	

APPENDIX *continued*

TUBERCULOSIS OF THE HIP—*continued*

Case No.	Sex	Age (yrs)	Total dose of streptomycin (*grammes*)	Nature of operation	Range of movement: Before operation	Range of movement: Last examination or follow-up	Duration of treatment	Additional evidence of tuberculosis	Remarks
44	F	5	75	Partial synovectomy	Nil	Almost full flexion	9 months	Microscopical confirmation	
45	F	3	32·5	Partial synovectomy	Nil	110° flexion	Discharge pending	Microscopical confirmation	Very active disease quiescent after 5 months' treatment
46	F	7	22·5	Partial synovectomy	10°	100°	19 months	Microscopical confirmation	Partial success: displacement osteotomy performed
				TUBERCULOSIS OF THE KNEE					
47	F	19	90 + P.A.S.	Partial synovectomy	80°	90°	4 months	Bilateral pulmonary tuberculosis	
48	M	45	90 + P.A.S.	Partial synovectomy	45°	45°	18 months	Multiple tuberculous lesions	
49	F	7	22·5	Partial synovectomy	120°	Full	8 months	Microscopical confirmation	
50	M	5	22·5	Synovectomy and curettage	Full	Full	8 months	T.B. in abscess	
51	F	18	90 + P.A.S.	Partial synovectomy	Full	120° flexion	6 months	T.B. in joint fluid	
52	M	20	90	Partial synovectomy	130° flexion	100° flexion	16 months	Multiple tuberculous lesions	
53	M	13	45	Partial synovectomy	70° flexion	90° flexion	8 months	Microscopy confirmed	
54	M	3	22·5	Partial synovectomy	45° flexion	5° flexion	15 months	Microscopy confirmed	Readmitted later for persistent sluggish disease
55	M	19	90	Partial synovectomy	70° flexion	90° flexion	6 months	Microscopy confirmed	
56	M	21	100 + 5 intra-articular	Partial synovectomy	90° flexion	90° flexion	6 months	T.B. in synovial fluid	
57	F	11	81 + 6 intra-articular	Partial synovectomy	15° flexion	100° flexion	11 months	T.B. in synovial fluid	
58	F	14	90 + 8 intra-articular	Partial synovectomy	45° flexion	120° flexion	11 months	Microscopy confirmed	Readmitted after 2 years with spinal lesion
59	M	16	74	Partial synovectomy		90°	9 months	Cold abscess present before admission	
60	F	18	69	Partial synovectomy	Full flexion	100°	9 months	Microscopy confirmed	Knee quiescent after 6 months. Flexion
61	F	36	97	Partial synovectomy	Nil	A few degrees	15 months	Pulmonary tuberculosis	Gross disease: painful ankylosis: excision
62	M	3	22·5	Partial synovectomy	5°	90°	9 months		

CALCIFYING ENCHONDROMA OF LONG BONES

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In examining radiographs of long bones, from time to time one comes across a film showing a sharply defined granular or flocculent deposit of dense calcium in the medulla in, or adjacent to, the metaphysis. Normal cancellous bone surrounds the calcium deposit. There is no change in size or shape of the bone nor is there any periosteal reaction. This is the appearance produced by a calcifying enchondroma.

In recent years a number of such calcified enchondromata have been identified at the Royal Sussex County Hospital. One was explored. Microscopic examination revealed bone and cartilage embedded in blood clot. The bone trabeculae were in general well preserved. Only small areas of cartilage appeared normal; the rest showed degenerative changes of varying degree, and small areas of calcification. No evidence of malignancy or inflammation was seen. A review of this and other similar cases was made to ascertain whether there were any special features that would enable the condition to be more readily recognised.

CASE REPORTS

Case 1—A woman aged sixty complained of pain in the left knee of three months duration. There was no history of injury. She walked with a slight limp. On examination there were tenderness and swelling over the lower end of the femur. The range of knee movements was normal. There was no increased heat and no effusion. Radiographs showed a flocculent granular deposit in the lower end of the femur (Fig. 1). The deposit was more dense round the periphery than at the centre. *Operation*—The lower end of the femur was explored from the lateral aspect. The periosteum was normal. A piece of the lateral cortex was removed to expose a thick grumous mass rather like inspissated tuberculous pus intermingled with blood clot. The histological appearance of the specimen has already been described in the opening paragraph. *Progress*—The post-operative progress was uneventful. Within two months the patient was free from pain. It was believed that relief was brought about by excision of the abnormal tissue.

Case 2—A woman aged fifty-five complained of intermittent pain in the neck and right shoulder for one year. The pain was not very severe but now tended to be more constant than ever before. There was no history of injury. *On examination* the predominant clinical sign was limited movement of the cervical spine. There was no swelling in the region of the neck or shoulder and no wasting in the muscles of either upper extremity. Movements at the right shoulder joint were full and painless. A radiograph of the cervical spine showed a narrow disc space at C 6–7 and osteoarthritic changes. Radiographs of the right shoulder showed a calcified mass in the upper part of the humeral shaft (Fig. 2). The cervical spine was treated with radiant heat and massage with complete disappearance of the pain and a return of normal mobility to the neck. It seems therefore that the mass in the humerus was in no way related to the signs and symptoms.

Case 3—A man aged sixty-four fell on his right arm and sustained a fracture of the upper end of the humerus. Radiographs showed, in addition to the fracture, a calcified mass in the upper part of the humeral shaft extending from the surgical neck downwards for three inches (Fig. 3). This had presumably been present for some time but the patient could not remember having had any previous symptoms in the arm. There was nothing in the radiograph to suggest that the calcified area had predisposed to the fracture; the fracture united satisfactorily.

Case 4—A man aged sixty-three complained of constant, but not severe, pain in his left knee for three months. There was no history of injury and on examination there was a small effusion in the knee and slight wasting of the quadriceps. Radiographs revealed a calcified mass in the lower end of the femur (Fig. 4). He was treated by quadriceps exercises and the symptoms subsided completely.

FIG. 1

FIG. 2

Figure 1—Case 1. Calcifying enchondroma. Localised granular deposit in the femoral metaphysis. Normal bone appearance elsewhere. Figure 2—Case 2. Normal shoulder joint but localised dense opaque deposit (calcifying enchondroma) in the humeral metaphysis. Normal surrounding bone.

FIG. 3

FIG. 4

Figure 3—Case 3. Flocculent opaque deposits (calcifying enchondroma) in the uppermost third of the humeral shaft. Normal texture of surrounding bone. Comminuted fracture at upper end of humeral shaft. Figure 4—Case 4. Heavy granular deposit (calcifying enchondroma) adjacent to the femoral metaphysis. No other bone changes.

Case 5—A man aged sixty-three slipped, twisting his left foot and knee. There was no history of his ankle giving way and on examination there was no clinical evidence of fracture but there was tenderness over the lateral ligament of the ankle. There was also slight tenderness over the medial ligament of the knee. A radiograph showed a calcified deposit, more dense at its centre than at the periphery, in the lower end of the femur (Fig. 5). The symptoms subsided without treatment.

DIFFERENTIAL DIAGNOSIS

The condition must be distinguished from 1) endosteal sarcoma, 2) Brodie's abscess, and 3) benign chondroblastoma of bone.

In *endosteal sarcoma* (Fig. 6) the involved area of bone may be greater than that affected by calcified enchondroma. Areas of bone destruction as well as of calcification are present but the density of the calcification is less intense. Usually some point can be seen where the bone surface is broken through. Periosteal reaction and local soft-tissue swelling are seen

FIG. 5

Case 5—Localised granular deposit in femoral metaphysis. Very similar to the calcifying enchondroma shown in Figure 1.

if the growth is in an advanced stage. If there is any doubt a biopsy should be performed to establish the diagnosis.

Brodie's abscess (Fig. 7)—The usual radiographic appearance is a sharply defined oval translucent area bounded by a thin sclerotic zone. Occasionally, however, it may be observed as a less well defined lesion and occupy a rather larger area, when the appearance might be confused with that of a calcifying enchondroma. Nevertheless in a Brodie's abscess of this type (Fig. 7) some areas of translucency can usually be identified; these are never seen in a calcified enchondroma. Moreover there is usually some, although slight, increase in the width of the bone.

Benign chondroblastoma of bone (France 1952)—This tumour, unlike an enchondroma, originates in the epiphysis though occasionally it may enter the metaphysis. It gives rise to a train of symptoms referable to the adjacent joint and there are muscle wasting, spasm and limitation of movement. Radiographically it is shown as an area of rarefaction throughout

FIG. 6

Endosteal sarcoma of femur showing as an ill defined dense mass arising centrally but reaching the bone surface posteriorly. Amidst the dense tissue there are rarefied areas due to bone destruction.

FIG. 7

Atypical Brodie's abscess. A collection of closely approximated well defined rarefied areas each bounded by a thin zone of sclerosis. Slight enlargement of the bone in a postero-medial direction.

which there are scattered areas of increased density. Biopsy shows characteristic giant cells and cartilage cells. A calcifying enchondroma produces no significant signs or symptoms and, radiographically, no rarefied bone is seen.

DISCUSSION

Stabler (1942) described two cases of degenerative enchondroma. Both were symptomless but biopsy was done in one and the report (by Dr W. W. Woods) stated: "Portions of spongy bone. The eosinophilous trabeculae are normal lamellar bone, and between some of them there is normal fatty marrow. But replacing the fatty marrow in most of the bone there are areas of solid haematoxophil tissue which are areas of chondroma. The matrix of the chondroma is in places hyaline, but much of it is fibrillar, having undergone mucoid change. The granular haematoxophil areas in the chondroma are areas of calcification." In all our cases except one the calcified mass in the bone presented as a non-clinical entity. The patients were all over fifty and gave no history of previous abnormality in the areas involved.

The first description of the radiographic appearances in calcified enchondroma was by Salinger (1928), who described five cases and stated: "The shadows appear in the long hollow bones. They are finely mottled, irregular, spongy, and in one case also an homogeneous shadow, and they are of such density that they stand out clearly in normal bones. It is noteworthy that the bone does not show any signs of destruction. Chalk content of the surrounding cancellous bone and cortex are normal. Even the outline of the bone is unaffected."

The condition was recognised by Virchow (1864) who at first termed them enostotic growths and indeed later called the enostosis a calcified enchondroma. Brailsford (1935) wrote: "In the lower third of the medulla of the shaft of the femur it is not unusual to see collections of calcium. These are indications of healed inflammatory foci, probably tuberculous in origin." In our cases it was noted in every instance that there was no interference with the architecture of the bone, nor was there destruction of bone or new bone formation. The argument against Brailsford's supposition is to be found in Stabler's and our own pathological findings.

Since most of these appearances have been found by accident in patients past middle age it is reasonable to infer that they have been present for a long time. It is also reasonable to suggest that in Case 1, in which there were symptoms referable to the site of the lesion in the lower end of the femur, the condition had not reached its final quiescent state.

SUMMARY

1. Five cases of calcified enchondroma are described. In all except one the condition was symptomless and was discovered accidentally.
2. The radiographic features are described and the differential diagnosis is discussed.
3. It is emphasised that when the diagnosis is in doubt biopsy should be undertaken.

We are greatly indebted to Mr R. Brooke for his interest and valuable advice during this investigation. We should also like to thank Mr J. M. Turner for the radiographs of Case 1, and Dr I. W. Hajdu for the histological report.

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LEONTIASIS OSSEA*

A Critical Review, with Reports of Four Original Cases

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This review is based upon 149 reported cases of leontiasis ossea, together with four cases that I have investigated and treated personally.

The term leontiasis was originally applied to elephantiasis of the facial skin complicating leprosy. Virchow (1864) described a patient with thickening of the facial bones as well as the skin and called it leontiasis ossea. It is now accepted that in true leontiasis ossea there is no thickening of the skin, and Virchow's original case was probably one of congenital gigantism of the face or of neurofibromatosis. Other authors have used the term for diffuse swellings in the jaws and for localised or diffuse swellings of the cranium. For the purpose of this review leontiasis ossea is defined as a generalised homogeneous swelling of the facial bones arising usually in the first decade of life. The swelling may spread to the lower jaw and cranium. The clinical picture shows an insidious onset of facial deformity with or without proptosis, nasal obstruction and impairment of vision. Pathologically and radiologically two main types may be recognised—in one there is sclerosis of the bones, associated mainly with infection; in the other there is an osteolytic process which is mainly unconnected with infection.

CLASSIFICATION

Many classifications have been suggested. Virchow (1864) thought that the condition arose simply as an inflammatory reaction in the periosteum—a "creeping periostitis." Many classifications (Bassoe 1905, Buhl 1878, and others) have included destructive conditions such as acromegaly and gigantism as leontiasis. Others have associated it with Paget's disease. Boit (1912) suggested that it was an endosteal reaction and cited osteitis fibrosa as a prime cause. Knaggs (1923*b*) differentiated two types—a "Virchow" type, or "creeping periostitis," a sclerotic process usually caused by trauma or infection; and a *diffuse osteitis* of the medulla of the bones. Other classifications have been suggested by Reiss (1935), Kienbock (1940), and Windholz and Cutting (1945). The main objection to most of these classifications is that they have included as examples of true leontiasis ossea conditions that can be clearly differentiated; these have tended to overshadow the importance of osteitis fibrosa and of polyostotic fibrous dysplasia, the association of which with leontiasis ossea was emphasised by Eden (1939), Falconer *et al.* (1942) and Etter and Hurst (1943). Recently Pugh (1945) and Schlumberger (1946) have suggested the association of monostotic fibrous dysplasia with leontiasis. I have preferred to classify leontiasis ossea as follows.

TRUE LEONTIASIS OSSEA

Type 1. Virchow's type or sclerotic type.†

Type 2. Fibro-dysplastic type which includes:
- Monostotic fibrous dysplasia.
- Polyostotic fibrous dysplasia.
- Albright's syndrome.
- Multilocular cystic disease of the jaws.

FALSE (OR SYMPTOMATIC) LEONTIASIS OSSEA

- Paget's disease.
- Congenital gigantism.
- Pituitary gigantism.
- Craniostenosis.
- Benign and malignant tumours of the nose and air sinuses.
- Syphilitic osteoperiostitis.

* Based on a thesis for the Doctorate of Medicine in the University of Cambridge, 1951.

† I prefer the term "sclerotic" type, because it suggests more directly the pathological and radiological features, which are in marked contrast to those of Type 2 leontiasis.

Of the 153 cases that have been studied, I have classified ninety-seven as examples of true leontiasis ossea. Of these, forty-five were of Type 1 and fifty-two of Type 2. Forty cases were classified as false (or symptomatic) leontiasis, and sixteen did not fall into either category (Table I).

ETIOLOGY

Type 1 leontiasis. *Injury and infection*—A history of trauma or infection is obtained in a large proportion of the patients. Out of forty-five reported cases thirteen were associated

TABLE I

CLASSIFICATION OF 153 CASES OF LEONTIASIS OSSEA
(149 reported cases and four personal cases)

True leontiasis ossea		97 cases
Type 1	45 (46·3 per cent)	
Type 2	52 (53·7 per cent)	
False leontiasis ossea		40 cases
Spyhilitic osteoperiostitis	8	
Paget's disease	6	
Pituitary lesions	6	
Craniostenosis	7	
Congenital gigantism	7	
Tumours of maxilla	6	
Unclassified		16 cases
Localised osteitis fibrosa	3	
Chronic hyperplasia of maxilla	2	
Dyschondroplasia	1	
Albers-Schonberg disease	1	
Neurofibromatosis	2	
Osteogenesis imperfecta with platybasia	1	
Albright's syndrome not showing leontiasis	1	
Paget's disease not showing leontiasis	1	
Meningioma	2	
Undiagnosed	2	

with injury and eleven with infection. Four others developed infection after the onset of the disease. Dacreocystitis is the commonest infection, though it is not always primary. Dental infection is more obviously primary. It is known that a chronic sclerosing osteomyelitis can arise from infection or after injury, either by interference with the blood supply or by organisation of a subperiosteal haematoma. Garré's chronic sclerosing osteomyelitis has been suggested as a cause (Freedman 1933, Windholz 1945, Pugh 1945). Knaggs (1923) suggested that infection was the main cause of this type but he could not substantiate it. Bailey (1939), however, reported a case of leontiasis in which there was a central Brodie's

abscess from which a streptococcus viridans was grown. In this case infection was obviously endosteal, but in another case in this series it arose in a subperiosteal haematoma. It should be remembered, however, that although a low-grade infection—possibly initiated by trauma—may determine the onset, subsequent severe infection can be produced by obstruction of the natural ostia of the antrum and naso-lacrymal duct by the hypertrophic bone.

Familial factors—In three cases of this series familial, and probably congenital, factors were of importance. These cases were no doubt allied to Frangenheim's (1914) "bilateral familial maxillary hyperostoses." They were mostly characterised by grotesque enlargement of the maxilla and secondary bone infection.

From Type 2—One Type 2 case changed to Type 1 after x-ray therapy. Another patient had the local sclerosis of the face typical of Type 1, whereas the vertex showed the osteoclastic areas of Type 2. This change is probably due to decreased vascularity brought about by radiation or by senile changes in the blood vessels.

Generalised osteosclerosis—There were two cases of generalised osteosclerosis in this group. One was due to Albers-Schönberg's disease and the other was Halliday's (1949) case which does not fall into any of the recognised varieties of this condition. Sclerosing conditions which may give rise to Type 1 leontiasis include osteopoikilie (which affects one half of the length of a bone), Engelmann's disease (which affects the shaft), osteopetrosis or "marble bones" (which affects the bone ends) and Leri's melorheostosis (which shows a spotted effect of the bone—"candle dripping"—at the ends).

There are also two monostotic types: the eburnising osteitis of Matti and the condensing osteitis of Sicard. In addition, chronic lymphoid or myeloid leukaemia may give rise to true sclerosis. It may be wrong pathologically to class these cases as Type 1 leontiasis. But clinically and radiographically they resemble other Type 1 cases. They also may explain the later age incidence of the condition in some patients of this group.

Type 2 leontiasis. *Injury and infection*—These may play a part. Out of fifty-two reported cases of Type 2 leontiasis, three were associated with trauma, and five with infection. But all of these eight cases were monostotic.

Developmental factors—Most of the congenital cases were monostotic. There were ten congenital cases of which one was polyostotic. In three familial cases the condition was mainly monostotic and was due to familial multilocular cystic disease of the jaws.

Monostotic and polyostotic fibrous dysplasia—These conditions show symptoms such as pigmentation, thyroid enlargement and large stature, which suggest an endocrine association. Many, in fact, are associated with Albright's syndrome. But pituitary hyperfunction produces gigantism and not fibrous dysplasia. Hamann (1920), on the other hand, suggested that fibrous dysplasia is due to hypofunction of the pituitary—a syndrome of atrophic genitals and bone cysts. Most patients with fibrous dysplasia are large for their age, and the pituitary factor must be kept in mind as a possibility.

Disease of the nervous system—Some cases have shown hypothalamic symptoms such as diabetes insipidus and inverted sleep rhythm. These also occur in the Stewart-Morel syndrome caused by hyperostosis frontalis interna, which many believe to be a type of fibrous dysplasia. Other cases were associated with a syringomyelic condition of the cord. It should be remembered that platybasia can give rise to a syringomyelic condition of the cord associated with stenosis of the foramen magnum, the etiological factor. This platybasia can be caused by Paget's disease, dyschondroplasia and fibrous dysplasia. Associated with platybasia, various types of lateral spinal tract sclerosis can occur. For these reasons I regard the neurological origins of this disease as tenuous. It is clear that they may arise mechanically as a secondary factor in many diseases of the skull in which bone softening occurs.

Primary liver disease must be mentioned because some cases were associated with icterus neonatorum. It is known that rarefaction and cortical thinning of bone may be produced in puppies who have an artificially produced obstructive jaundice.

PATHOLOGY

Gross examination shows an enlargement of the facial bones which may be associated with swelling of the jaws and cranium. There is never any thickening of the skin; when the swelling is pronounced the skin is markedly thinned. The diploe of the cranium and the outer plate are affected.

In Type 2 leontiasis the swellings are more exuberant; the bones are softer and may even show egg-shell crackling; and there is usually more pressure on surrounding structures such as the eye and the nose. The bones most commonly affected are the anterior and orbital plates of the frontal, the orbital plate of the ethmoid, the zygoma and the maxilla. In Type 1 cases the antra are frequently obliterated. The bones of the middle fossa show sclerosis in all cases, but especially in Type 2.

Histology. *Type* 1—From an endosteal or periosteal stimulus there is a fibrous-tissue and osteoid hyperplasia of the medulla. The periosteal new bone is formed from fibrous bone and may arise from an endosteal or periosteal focus. The general histology is that of osteoblastic and fibroblastic activity with a minimum of osteoclasts or giant cells.

A similar histological picture will be found in cases of chronic hyperplasia of the maxilla (Westmacott 1913) and in chronic sclerosing osteomyelitis (Thoma 1941).

Type 2—There is a fibrous enlargement of the medulla which expands and atrophies the cortex. The medulla is full of fibroblasts, osteoid tissue and giant cells, in varying proportions. In many cases and in all active phases no osteoid tissue will be found at all (See Case 1 and Fig. 3). In the regenerative phase, fibrous bone will be seen growing as a metaplasia between medulla and cortex.

CLINICAL FEATURES

Sex and age incidence—*Type* 1—There were thirty-one males and fourteen females. This male preponderance is attributed to a greater liability to trauma or infection. The average age at onset in this type was 18·4 years. *Type* 2—There were twenty-four males and twenty-eight females. The average age incidence was seven years (a number of congenital cases are included).

Disease incidence—According to Fairbank (1950) the skull is affected in one-third of all cases of polyostotic fibrous dysplasia and in two-thirds of the cases of Albright's syndrome. Schlumberger (1946) found the facial bones affected in 20 per cent of sixty-seven cases of monostotic fibrous dysplasia. My own research has revealed records of ninety-seven true cases in a period of 180 years. This indicates that the condition is rare, especially if it is restricted to the classification suggested here.

Symptoms—There is a history of an insidious onset of facial swelling, noticed in early infancy. The swelling remains unilateral for some time and the child is brought up to the doctor because of facial asymmetry. At this stage there are few symptoms beyond facial pain or neuralgia. Later, at ten to fourteen years, the child complains of nasal obstruction or proptosis. Later still there may be impairment of vision, especially a restriction of the visual fields. Finally, the secondary effects produced by the large hyperostotic mass will give epiphora, sinus infection, headache and neuralgia. Headache is common and is usually a local pressure symptom. It has been suggested that headache and coma from raised intracranial pressure are common, but I believe that this is due to an erroneous diagnosis of leontiasis being made in cases of craniostenosis or meningioma. Raised intracranial pressure was proved in only six cases of true leontiasis. Rarer symptoms are dysphagia, difficulty in closing the mouth, and difficulties of speech.

Signs—If the tumour is large the skin is stretched and thinned. The swelling involves the maxilla, zygoma or frontal regions. There may be associated swellings in the cranium or

mandible. The tumour may be unilateral at first (Fig. 1), but becomes more diffuse later. The nose may sink in between two paranasal swellings. This is a particular characteristic of the false type syphilitic and of Frangenheim's variety of Type 1 leontiasis.

Nasal signs—Nasal stenosis is the commonest finding (twenty-two cases in this series). The block is due to pressure of the tumour on the lateral wall. It may extend into the nasopharynx and block the posterior choana. In Type 2 the signs of sinus disease are also present. *Eye signs*—Proptosis alone was present in fourteen cases. It was found associated with optic neuritis and epiphora in thirty-four cases (twenty of these were of Type 2). Optic neuritis is caused either by stretching of the optic nerve on the floor of the orbit or by pressure on the nerve in the optic foramen. *Neurological signs*—Frontal headache and frontal pain suggest involvement of the fifth nerve, especially the supraorbital and infraorbital branches. This headache has been relieved by freeing the nerve from the surrounding bony tissue. Hemianaesthesia of the face and tic douloureux have been observed. The seventh and eighth nerves were not affected in the cases reviewed. *Mouth signs*—The gums are thickened and oedematous and the teeth show disorderly growth, especially in Type 2. Swelling of the palatal process of the maxilla is more commonly found in Paget's disease, but was observed in two cases of true leontiasis.

RADIOGRAPHIC FEATURES

Type 1—The abnormality may take three forms. 1) There is a localised sclerosis beginning in the maxilla and spreading over the frontal bone, and sometimes to the cranium and lower jaw. This is the classical picture. 2) The sclerosis is not complete but is etched out by small translucent patches and areas of normal bone (as in Type 2). This is seen in Frangenheim's cases and also in my Case 4 (Fig. 9). 3) Sclerosis of the face is associated with a generalised sclerosis affecting other parts of the skeleton, as in Albers-Schönberg's disease. The sclerosis may be periosteal or endosteal. The antra are dull in Type 1 and often obliterated by the fibro-osseous mass. The sclerosis may affect the cervical vertebrae, but the inner table of the skull is not affected.

Type 2—The following changes may be observed. 1) The facial bones show the typical trabeculated and cystic appearance of a localised osteitis fibrosa. The cortex may be seen as a paper-thin shell (Fig. 2). 2) The base of the skull shows sclerosis, a characteristic finding. 3) The calvarium is thickened and may present an appearance similar to that of Paget's disease except that the inner table is intact. 4) Osteoporosis circumscripta cranii occurs frequently. It occurs at least as often as it does in Paget's disease. It is said that 20 per cent of patients with osteoporosis circumscripta cranii show leontiasis or tumours of the maxilla. There were eight cases in this review (six in Type 2 and two in Type 1 cases) (Fig. 9).

DIAGNOSIS

The clinical history of proptosis, nasal stenosis and swelling of the face starting in the first decade of life will suggest the diagnosis. The other important investigations are the radiographic examination and biopsy. The whole skeleton should be radiographed. *Biopsy* is important in excluding such conditions as osteoclastoma and osteitis deformans. It is less useful in separating the various types of fibrous dysplasia.

DIFFERENTIAL DIAGNOSIS

Symptomatic leontiasis ossea differs from the true variety in etiology, clinical features and pathology. The conditions listed below are those that are most frequently mistaken for leontiasis ossea. Some, such as congenital gigantism of the face, are easy to diagnose. Others, such as congenital syphilitic osteoperiostitis of the face, are almost identical with true leontiasis ossea.

Paget's disease—In the facial region Paget's disease has distinctive clinical features. There is an insidious onset of facial disfigurement, facial pain and deafness arising in the fourth or fifth decades. There is never any interference with vision and the maxilla is affected only in its prealveolar part. The other bone commonly affected is the zygoma. Of eight patients with Paget's disease of the face in this review only one had affection of the lower jaw alone; in all the others the upper jaw was affected. Four had deafness, three suffered from headache, one had poor vision and two had no symptoms beyond facial disfigurement. Only one had nasal stenosis, and proptosis was not observed. The radiographic appearances and histology differ from those of leontiasis ossea.

Partial congenital gigantism—Five cases in the series were examples of partial congenital gigantism, but were listed as leontiasis ossea (those of Kiwull 1890, Clément *et al.* 1943, Starr 1894, Port 1904 and Barwell 1881). Partial congenital gigantism of the face or hemihypertrophia faciei et colli (Hamann 1951) is a hypertrophy of all the tissues (including bone) of the face, neck, mouth, tongue and oropharynx, confined strictly to one side. The lips and teeth are most commonly enlarged. It is associated with hyperaemia, pigmentation and marked thickening of the skin. The only atypical case was that of Starr, in which the whole head, whole face and whole neck were enlarged.

Congenital anomalies of the skull—Anomalies of skull development may bear a striking resemblance to leontiasis ossea. The most important is *brachycephalus*, in which the head is broad, short and round. There are three types of this abnormality: 1) oxycephalus (turricephalus, tower or steeple head); 2) plagiocephalus (asymmetrical skull); and 3) acrocephalus (high projecting forehead). In *oxycephalus* there is early closure of all sutures, especially the sagittal and coronal. The skull grows upwards into a point. There are exophthalmos, prominent zygomatic bones, enlarged temporal fossae and raised intracranial pressure. Mentality is usually normal. Other defects, such as syndactylism, occur. This is the commonest congenital anomaly of the skull. *Plagiocephalus* is essentially unilateral oxycephaly. The skull grows upwards, but only on one side. *Acrocephalus* is believed to be due to premature fusion of the sagittal sutures near the bregma. The frontal bone bulges upwards and forwards. This type is very often associated with syndactylism, a combination known as Apert's syndrome. In all of these three conditions there may be a swelling in the frontal, temporal or zygomatic region, proptosis or exophthalmos, headaches, fits and, frequently, blindness. The conjunction of swollen face, proptosis and disturbance of vision gives the false picture of leontiasis ossea.

In this series there were seven cases of congenital skull anomaly. Two were due to plagiocephaly, three to oxycephaly and two had insufficient evidence on which to classify them.

Other congenital affections, which may be associated with these main defects and give confusion, include *Crouzon's disease* (cranio-facial dysostosis) in which there are a prominent frontal bone, hooked nose, heavy lower lip, prognathism and high arched palate; *Dzierzynsky's syndrome* (periostalis hyperplastica familiaris), a combination of acrocephaly, syndactyly and a massive skeleton in which there are convolutional atrophy of the brain, a large sella turcica and rudimentary or absent sinuses; *hypertelorism* (Greig 1924), in which the width between the eyes is increased and there is bulging of the frontal lobes of the brain and protrusion of the frontal bones (Fig. 2); *gargoylism* (Hurler 1919), in which there may be frontal bossing and facial concavity, with some sclerosis of the bones; and *cephalonia*, a rare condition in which there is an increase in the brain contents and consequent macrocephaly.

Syphilitic osteoperiostitis—Eight cases of syphilitic osteoperiostitis in this series were listed as leontiasis ossea. Seven were due to latent congenital syphilis and one to acquired syphilis. In half the cases the swellings were paranasal and arose insidiously at about the age of seven and were associated with other syphilitic stigmata. These cases bore a striking resemblance to goundou. But the others were not typical. Ilg's (1821) case showed enormous

enlargement of the whole face; Pulet-Laherre's (1887) case an opaque sclerosis of the face and cranium. Lapeyre's (1937) case showed the normal distribution and radiographic appearance of true leontiasis of Type I. It is probable that syphilis in the latter case was coincidental.

The commonest symptom of syphilitic osteoperiostitis was nasal stenosis. Other symptoms were headache, facial neuralgia, dimness of vision and ataxia. Differential diagnosis may be difficult, for almost the only points of distinction from true leontiasis ossea are the syphilitic stigmata, the nasal attachment of the hyperostoses and the usual family history of miscarriages. The paranasal type is very similar to Frangenheim's bilateral familial maxillary hyperostoses. Study of the records, however, shows that there was a vigorous search for syphilitic signs in all Frangenheim's cases without any being found.

Pituitary dysfunction—There were six cases of pituitary dysfunction in the series. Two did not even show symptomatic leontiasis ossea. Of the other four, three were due to gigantism and one to acromegaly (the cases of Bassoe 1905, Buhl 1878, Saucerotte 1801 and Sattler 1900). All showed classical hyperpituitarism. In addition they all developed hyperostoses of the maxilla, and all subsequently developed raised intracranial pressure. Acromegaly should never be confused with leontiasis ossea, because of the thick lips and tongue and the marked prognathism. While it is possible that there may be a pituitary factor in leontiasis, acromegaly and gigantism are clinically quite distinct from the true leontiasis.

Primary bone tumours of the maxilla and nasopharynx—Three malignant tumours in the series have been named as leontiasis ossea. They were a sarcoma of the maxilla, a carcinoma of the maxilla and a nasopharyngeal fibrosarcoma. The symptoms and signs are sufficiently distinct to need no further differentiation. Benign tumours to be borne in mind include the following: 1) Ivory osteoma, which may be unilateral or bilateral. An osteoma of the frontal sinus may cause proptosis and nasal stenosis. 2) Osteoclastomata, which may easily be distinguished by the radiographic findings and biopsy. 3) Adamantinoma, which has a complex but characteristic pathology. It is found usually in the lower jaw. 4) Ossifying fibroma (fibro-osteoma or fibro-osteoid osteoma). The maxilla is commonly affected, with consequent proptosis. Its pathology is under discussion.

Other conditions—Occasionally confusion may be caused by the following: 1) Dyschondroplasia. I found one case in the series and that case showed none of the classical signs of leontiasis ossea. Typically in this disease the face is concave. 2) Meningiomas. There were two possible cases in the series. Many authors refer to the "hemicraniosis of Brissaud and Lereboullet" as a cause of true leontiasis ossea. In referring to Brissaud's original paper I found the phrase "une double lesion ossée et meningée." In fact the cases were meningiomas with reactionary bone formation in the fronto-parietal region. The main clinical features are swelling of the forehead or cranium, with headache, vomiting and exophthalmos. The lesion starts first on the inner table, as opposed to the diploe in fibrous dysplasia. 3) Hyperostosis frontalis interna. This is a thickening of the inner table of the frontal bone occurring in women of thirty to forty-five. It may be associated with the Stewart-Morel syndrome, in which two of the common symptoms are dimness of vision and convulsions. 4) Secondary malignant deposits. 5) Erythroblastic anaemia, in which there may be thickening of the frontal bone from proliferation of the diploe. 6) Multiple neurofibromatosis (von Recklinghausen). Beneath the diseased skin, lesions of the bone are often found. They may produce kyphoscoliosis or a congenital dysplasia of one or more bones leading to local gigantism. Cyst-like areas are found in the skeleton. This disease could show many of the features of congenital facial hemi-hypertrophy. In one, gigantism follows the course of nerves, in the other the swelling goes up to the midline. In both there may be hypertrophy of the cervical vertebrae, and pigmentation. Two cases in this series of leontiasis were found to be examples of neurofibroma. In one there was a neurinoma of

the optic nerve and in the other there was generalised neurofibromatosis. 7) Myelosclerosis. A condition of bony thickening and sclerosis is found associated with anaemia, aleukaemic leukaemia and leukaemia. 8) Lipoid granulomatosis. The Hand-Schüller-Christian variety shows clear-cut defects of the skull together with exophthalmos and diabetes insipidus.

PROGNOSIS

The prognosis in leontiasis ossea is better than was thought. In one-third of the patients facial disfigurement is the only symptom. Visual lesions are serious but they occur in only 20 per cent of cases. A patient who has no eye signs at twenty years of age will never develop optic neuritis. It seems probable that the bad prognosis which has been suggested by some is due to the associated diseases that have been listed wrongly as leontiasis. In this series the cases of pituitary adenoma, craniostenosis and syphilitic osteoperiostitis had a grave prognosis both for vision and life.

Out of ninety-seven patients with true leontiasis ossea thirty-one had no symptoms or signs beyond swelling of the face; twenty-three had nasal obstruction, epiphora or dacreocystitis; nineteen had signs of local pressure on the eye or optic nerve; seven had headache or neuralgia; and eight had symptoms and signs of raised intracranial pressure. There were only four deaths. The incidence of complications was 12 per cent, but they were usually of the mild variety. Perusal of the case histories shows that operation improves the prognosis for vision in nearly all cases and especially if the surgical intervention takes place soon after the onset of symptoms.

TREATMENT

In view of the good prognosis, prophylactic removal of the mass is unjustified. The treatment is mainly symptomatic. The most important step is to check and relieve the eye signs by decompression of the optic nerve. Operations such as Kronlein's lateral orbitotomy, transfrontal orbitotomy or sub-zygomatic decompression may be necessary according to the position of the growth. Nasal stenosis may require treatment by resection of the septum and chiselling down the floor of the nose. Associated sepsis, in the form of antral empyema, ethmoiditis, dental infection, dacreocystitis or gingivitis may need appropriate treatment. Neuralgia of the fifth nerve, with headache, may require operation. This may be a question of dissecting the nerve out from its ensheathing bone as in Moore's case. Or it may require injection or section of the ganglia of the nerve or one of its branches.

Probably the commonest surgical treatment in the proved Type 2 cases will be to restore a normal facial contour by plastic operations.

X-ray therapy—This may be used alone or in conjunction with surgery. It has been proved to have a benificial effect in all cases. There is regression both in the size of the bony tumours and in the symptoms. Dosage recommended is 2,000–3,000r.

CASE REPORTS

Case 1—Girl aged sixteen years. History of gradual onset of swelling of right side of face at age of seven years, after a blow on the cheek. The swelling gradually enlarged and spread to the other side of the face and both lower jaws (Fig. 1). No further increase in size during last eighteen months. Parents dead, but photographs of father and mother showed no facial disfigurement. Child complained of nasal congestion and catarrh. No visual symptoms. On examination, the thickening was found to involve the maxillae, mandible, zygomas (especially right), ethmoids, sphenoid, and base of skull. The calvarium was unaffected. There was bilateral proptosis. There was some limitation of airway in both sides of the nose, from hypertrophic mucosa. Visual activity was 6/5 in each eye; the fundi were healthy; there was slight restriction of both visual fields. Examination of the central nervous system revealed no abnormality.

Investigations—Haemoglobin 81 per cent. Red blood cells normal. White cells 10,350 (76 per cent polymorphs). Plasma phosphate 3·1 milligrams per cent; calcium 12 milligrams per cent; cholesterol 115 milligrams and 174 milligrams per cent; alkaline phosphatase 8·3 units. *Urinary calcium*—Excretion, twenty-four hours, 875 cubic centimetres; inorganic phosphate 1·2 grammes (normal

FIG. 1

FIG. 2

Case 1. Figure 1—Multilocular cystic disease of the jaws, or "cherubism," causing leontiasis ossea (Type 2). Note the gross enlargement of the right mandible, right maxilla and right zygoma. There is also proptosis and some swelling of the jaws on the left side. Figure 2—Lateral radiograph of skull, showing the cystic condition of both upper and lower jaws, the sclerosis of the basi-sphenoid and the normal cranium. There is gross malalignment of the teeth.

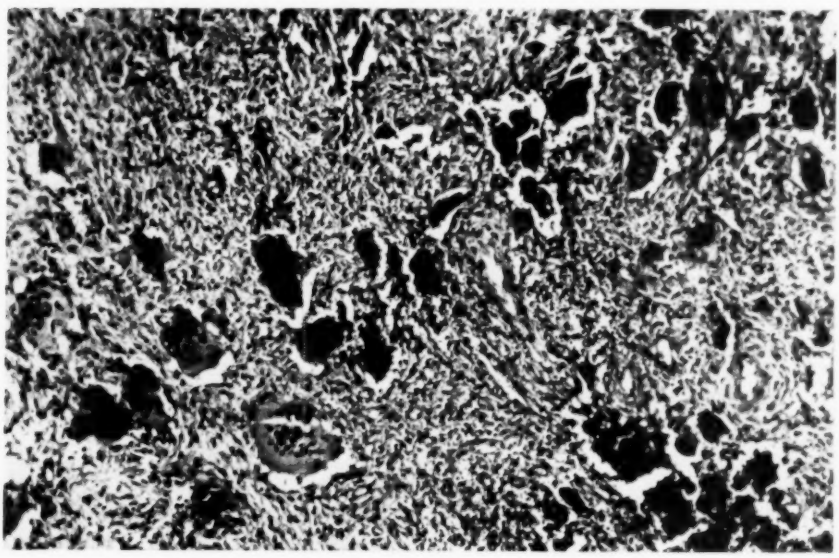

FIG. 3

Case 1.—Photomicrograph of section from maxilla, showing giant cells in a mass of fibroblastic tissue.

1–5 grammes per day); calcium 177 milligrams (normal 10–300 milligrams). *Sternal puncture*—Slight eosinophilia but otherwise normal marrow. *Lumbar puncture*—Normal findings.
Radiographic examination—There was a generalised cystic appearance of the facial bones and mandible (Fig. 2). Some trabeculation was present, but it was *not* of the regular pattern found in osteoclastoma. The cystic changes involved the ethmoidal a*nd* sphenoidal air sinuses. There was some sclerosis of the base of the skull, but the calvarium was unaffected. The teeth were ill-developed and malaligned, lying at all angles in the jaws. Some of the molar teeth were unerupted. The antra were opaque. The rest of the skeleton was normal, except for slight notching of the medial aspect of both humeral epiphyses, said to be characteristic of leukaemia (Golding 1950).
Biopsy—Material was taken from the right maxillary swelling. *Gross findings*—The cortical bone was paper-thin. The medulla was increased, and filled with a soft, spongy mass. The bone was bluish at its surface, and cut easily. It could be dented by pressure, with a sensation of "egg-shell" crackling. The periosteum as such was not identifiable; the whole subcutaneous area was thickened and fibrotic. *Histology*—The main mass consisted of fibroblasts in an expanded medulla, with scattered giant cells of the osteoclast type (Fig. 3). There were no giant cells in the subcortical fibrous zone. There was no suggestion of osteoid tissue; no lipoid and no haemosiderin.
Treatment—At the time of biopsy the right maxillary antrum was opened and found to be normal except for the presence of an unerupted canine tooth. The left antrum was opened later and found clear. The disfiguring facial mass was excised by a plastic operation, undertaken in two stages.

Comment—The radiographic appearances were striking. They did not resemble those of focal osteitis fibrosa, von Recklinghausen's disease of bone, osteoclastoma, or odontogenic cyst. But they were like those published by Jones *et al.* (1950) in their cases of familial multilocular cystic disease of the jaws ("cherubism"). Histologically, the profusion of giant cells was unlike the usual findings in fibrous dysplasia or focal osteitis fibrosa, although Thoma (1941) believed that the presence of giant cells was not inconsistent with fibrous dysplasia. Like the radiographic findings, the histological appearances were those of Jones's cases of cherubism. There was no evidence in this case, however, of a familial incidence. This case is classified as true leontiasis ossea, Type 2, caused by multilocular cystic disease of the jaws.

Case 2—Man aged fifty-seven years. Complained of increasing swelling of face which began fifteen years before—about a year after extensive removal of teeth. Had also noticed general enlargement of head. Bilateral deafness and tinnitus for six years. No headache or facial pain.

On examination, there was marked swelling of the upper jaw, especially in the pre-alveolar region (Fig. 4). The lips were protruded by the swelling, but there was no proptosis. Examination of the ears showed normal tympanic membranes. Bone conduction much reduced, especially on the right. Negative rinné test both sides. Nose—There was some hypertrophy of the mucous membrane on the left side, but no nasal stenosis. The eyes were normal.

Radiographic examination showed typical appearance of Paget's disease in the pelvis, and in the maxilla and calvarium (Fig. 5). There was an osteoma of the right frontal sinus and opacity of the left antrum.

Investigations—Serum calcium 9·8 milligrams per cent; inorganic phosphorous 2·6 milligrams per cent; alkaline phosphatase 15·3 units.

Treatment—Left intranasal antrostomy was undertaken for relief of a chronic empyema of the left antrum. No other treatment was considered necessary.

Comment—This case is classified as false leontiasis ossea due to Paget's disease involving the maxilla. Distinctive features, not present in true leontiasis, were the pre-alveolar swelling and perceptive deafness, and the absence of nasal stenosis or proptosis.

Case 3—Girl aged seven years. Insidious onset of right facial swelling and right proptosis for three years. The swelling had increased gradually. Tendency to right epiphora. No neurological or visual symptoms.

On examination there was swelling of the right zygoma and right temporal region, with proptosis (Fig. 6). The eyes were widely spaced, the right being lower than the left. The ophthalmologist reported hypertelorism in a congenitally defective skull; vision 6/18 each eye; alternating divergent and paralytic squint; media clear; fundi normal.
Radiographic examination—The lesion affected the skull, right zygoma, right temporal bone, parts of right parietal and right frontal zone. The skull showed the "beaten silver" appearance of

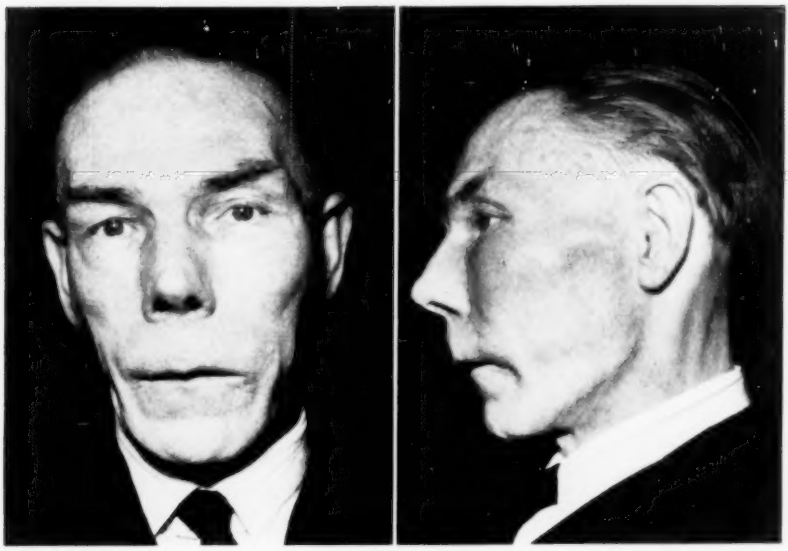

FIG. 4

Case 2—Paget's disease of skull and face causing false leontiasis ossea

FIG. 5

Case 2—Radiograph showing typical Paget's appearance of the skull and face.

FIG. 6 FIG. 7

Case 3. Figure 6—Craniostenosis causing false leontiasis ossea. Note the proptosis on the right side, and the bony swelling in the right zygoma, right temporal region and right supra-orbital region. Figure 7—Antero-posterior radiographs of the skull showing the "beaten-silver" appearance of craniostenosis. Note the bony hypertrophy corresponding with the site of swelling as seen in Figure 6.

craniostenosis, with a bony thickening in the region of the right zygoma (Fig. 7). Tendency to placiocephaly.

Treatment—Expectant treatment has been planned.

Comment—This case is classified as false leontiasis ossea due to craniostenosis. The bony hypertrophy was marked. This, with the proptosis, rendered confusion with true leontiasis easy. The cause of the bony hypertrophy was presumably connected with alteration of the bony mechanics of the skull; the cranial contents were protruded in those areas in which there was no premature synostosis.

Case 4—Man aged fifty-nine years. At almost the age of twenty years he first noticed a swelling of the left side of the forehead, which slowly increased in size for ten years. He attributed the onset of the swelling to a blow on the head. The swelling was symptomless; it was observed when he reported for treatment of osteomyelitis of the left maxilla. The osteomyelitis responded to penicillin. There was a history of old bilateral otitis media.

On examination, the main swelling affected the left frontal area, which was thickened as far back as the left parietal suture (Fig. 8). There were other exostoses in the left parietal suture and left occiput, but these were separate from the main mass. Both maxillae and both zygomas were enlarged. Ears—There was deafness due to old bilateral suppurative otitis media. Eyes—The visual field on the nasal side of the left eye was restricted.

Radiographic examination showed that both maxillae and the left frontal, parietal and occipital bones were the seat of fibrous dysplasia. There was sclerosis of the base of the skull, the face, and the frontal region especially (Fig. 9). Farther back there were cystic areas typical of fibrous dysplasia and localised areas of osteoporosis circumscripta cranii. The rest of the skeleton was normal.

Investigations—Serum calcium 10·2 milligrams per cent; phosphate 4·2 milligrams per cent; alkaline phosphatase 20·2 units. Urinary calcium excretion was normal. An osteomyelitic cavity in the left maxilla was excavated. The removed bone showed only the changes of osteomyelitis. Biopsy of the main mass was not undertaken.

Comment—The appearance of the calvarium suggested true leontiasis ossea of Type 2 (fibrous dysplasia). Nevertheless there was so much sclerosis anteriorly that the case was classified as true leontiasis Type 1, associated with osteoporosis circumscripta cranii. Strictly,

FIG. 8

Case 4.—True leontiasis ossea (Type 1). Note the marked enlargement of the left maxilla and left frontal region.

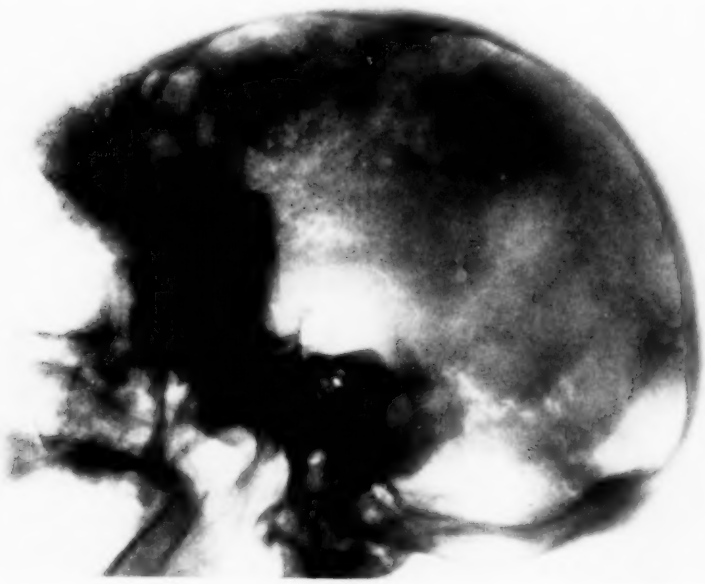

FIG. 9

Case 4.—Radiograph showing the fibro-dysplastic areas in the cranium, and sclerotic bony hypertrophy of the base of the skull, the frontal bone and the maxillae. In the frontal bone the mottled appearance characteristic of fibro-dysplasia is clearly seen. (See text for discussion on diagnosis.)

it is a mixed type. The development of osteomyelitis suggests that the fibrous bone is more susceptible to infection than normal bone. It has been noted that when fibrous dysplasia begins relatively late in life, as in this case, the tendency is for the bone to become more sclerotic than usual, and for the symptoms to be slight.

SUMMARY AND CONCLUSIONS

1. One hundred and forty-nine cases of leontiasis ossea reported in the literature have been reviewed.
2. The clinical, radiographic and pathological features of the condition are discussed.
3. Four additional personal cases are reported in detail.
4. A new classification of leontiasis ossea is suggested, by which the condition is divided into *true leontiasis* and *false* (or *symptomatic*) *leontiasis*. True leontiasis is a clinical syndrome caused by two distinct types of disease, whose pathology, however, is related. False leontiasis gives a superficially similar picture but on detailed examination is found to be distinct; it may be caused by a variety of different conditions.
5. Classified in this way, ninety-seven of the total of 153 cases considered were classified as true leontiasis (forty-five Type 1 and fifty-two Type 2); forty were classified as false leontiasis; and sixteen did not fall into either category.

I would like to thank Dr Woodhouse-Price for his help with the pathology. Mr Malley, Mr Lewis and Mr Doey have allowed me to use their cases, for which I am very grateful. It is a pleasure to acknowledge the help and advice I have received from Mr Negus and Professor Ian Aird in the preparation of this article.

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MYOSITIS OSSIFICANS PROGRESSIVA

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Mather (1931) and Ryan (1945) affirm that this disease occurs exclusively in the white race. Our case, being in an Indian native child, is therefore of interest. So far only 161 cases of this rare disease have been reported in the world literature.

Fig. 1

Fig. 2

Figure 1—The child trying to abduct his shoulders and to open his mouth; the jaws cannot be separated. Both elbows ankylosed. Figure 2—Generalised kyphosis, and a bony nodule on the back.

Fig. 3

Fig. 4

Figure 3—Microdactylia of great toes and hallux valgus of both feet. Figure 4—The proximal phalanx of the hallux is dislocated laterally and lacks a basal epiphysis. This may perhaps be represented by the anomalous centre at the head of the first metatarsal bone.

CASE REPORT

A seven-year-old Indian complained of inability to open his mouth, and of progressive stiffness of the back and limbs since infancy. He was healthy till he was six months old,

when firm nodules appeared on the back and gradually increased in size. After another six months a fresh crop of nodules appeared about the shoulders. During the next year, all these nodules started to become smaller, but bony hard. In the last three and a half years the joints have become stiff; he cannot open his mouth, so that he is restricted to a semi-solid and liquid diet, and he has to be fed because his hands do not reach his mouth. *Family history*—A careful history failed to reveal any affection of relatives. Of two elder brothers, one has spinal caries.

Clinical examination—He was apparently a well built and well nourished child. The mouth could not be opened. The neck was short, stiff and immobile (Fig. 1). Respiration was diaphragmatic. Only the left side of the abdomen moved. There was a generalised kyphosis (Fig. 2). A continuous bony ridge was felt along the antero-lateral aspect of the whole of the right half of chest and abdomen, extending down to the right iliac crest. *Upper Limbs*—Gleno-humeral movements were absent, but there was slight mobility of each scapula on the

Fig. 5

Fig. 6

Figure 5—New bone in muscle of mastication. Figure 6—Continuous bony ridge on the front of the right chest and abdomen.

chest. The right elbow was ankylosed at 120 degrees, and the left at 130 degrees. The wrists and hands were normal in shape, size and movements. *Lower limbs*—The right hip was fixed in flexion at 90 degrees. Left hip movements were normal. The knees were flexed, but movement was possible through 5 to 10 degrees. There was microdactylia of the great toes (Fig. 3) with hallux valgus. Ankle and foot movements were normal. *Urine*—Normal.

The patient was able to sit on a stool, but was unable to walk even with the help of crutches because his arm muscles were too weak.

Radiographic examination—Figure 5 shows bone formation in the muscles of mastication. Figure 6 shows the continuous bony ridge on the front of the right chest and abdomen. Figure 7 shows bone in the sternomastoids. Figure 4 shows shortening of each great toe; its proximal phalanx is dislocated laterally and is without evident basal epiphysial centre, but this may be represented by an anomalous centre of ossification adjacent to or fused by cartilage to the first metacarpal bone.

Pathological examinations. *Blood*—Total white cells 16,000 per cubic millimetre; polymorphs 42 per cent; lymphocytes 34 per cent; mononuclears 2 per cent; eosinophils 22 per cent. Serum calcium 10·6 milligrams per cent; inorganic phosphates 4·37 milligrams per cent. Alkaline phosphatase 3·23 units per cent. V.D.R.L. and Meniki negative. *Stools*—Repeated examination for parasitic infections was negative.

Operation—A piece was removed from the ridge of bone on the right abdominal wall. Bone formation recurred with added zeal.

COMMENT

The disease is characterised by generalised ossification of the skeletal muscles. Really it is fibrositis ossificans progressiva (Greig 1931) for muscle fibres are not primarily ossified. The cause is unknown. Biochemical investigations have shown no appreciable change either in the blood chemistry or in the internal secretion of ductless glands. Münchmeyer (1869) described the histology, which is well summarised by Frejka (1929).

FIG. 7
Bone in the sternomastoids.

Frejka distinguished four types. 1) The usual type, slow and gradual in onset, occurs insidiously in early childhood: our case falls into this category. 2) A type that begins with inflammation of some sort: his own case and some others belong to this category. 3) A type beginning with trauma: new bone forms with each injury. 4) Bone formation after transverse lesion of the spinal cord (myositis ossificans neurotica)—a distinct condition.

Except in a singular case of Rosenstirn, in which ossification extended into the subcutaneous tissues, ossification remains confined to voluntary skeletal muscles, tendons and ligaments. The disease is progressive, though liable to some waxing and waning. The hands and feet escape and the rest of the body becomes bony stiff. Death occurs from intercurrent disease or from chronic starvation due to ossification of the muscles of mastication. Removal of the bony masses results in reappearance of new bone, often in increased amounts.

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THE TRUMBLE GRAFT

A Review of Thirty-six Cases

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In 1932 Trumble described "A method of fixation of the hip joint by means of an extra-articular bone graft," and reported three cases, all with successful results. In a later paper (1937) he reported five further cases: four were successful, but in one the graft failed to fuse with the ischium, allowing slight though painless movement at the hip joint. Four subsequent operations were all successful (Girdlestone 1940).

The operation—Briefly, the technique of the operation, as originally described, is as follows. Before operation, a plaster bed with a foot extension is prepared, the limb being placed in slight flexion at the knee and hip, and slight abduction at the hip—that is, in the best position

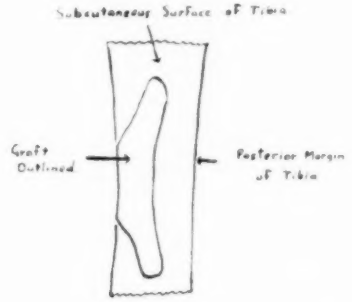

FIG. 1

Shows the method of obtaining a shaped graft from the tibia. (After Trumble.)

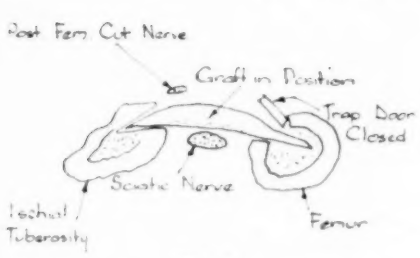

FIG. 2

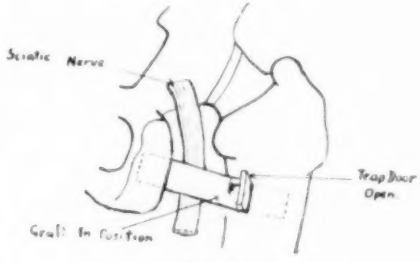

FIG. 3

Figure 2—Diagrammatic horizontal section showing graft in position. (After Trumble.)
Figure 3—Diagram showing graft in position, as seen from behind. (After Trumble.)

for ankylosis. A large dummy dressing is applied over the site of the proposed incision. The standard approach to the sciatic nerve is used, the gluteus maximus being reflected from its insertion. The posterior part of the ischial tuberosity is split off with a chisel, leaving an open cleft for the reception of the graft. An area just below the lesser trochanter, on the postero-medial aspect of the femur, is selected and cleared. A three-sided flap of bone is elevated, still attached by periosteum on its fourth side, to act as a "trapdoor." A strong graft is cut from the tibia (Fig. 1); it is sprung into position between femur and ischium, penetrating deeply into each, and the "trapdoor" is sutured at its edges (Figs. 2 and 3).

TABLE I

ANALYSIS OF THIRTY-SIX CASES OF ISCHIO-FEMORAL ARTHRODESIS BY THE TRUMBLE TECHNIQUE

Case number	Follow-up period	Character of graft			Result	Comment
		Length	Width	Position		
1	12 years	Moderate	Wide	Transverse	Successful	Graft fractured at centre, but united
2	2½ years	Short	Wide	Transverse	Successful	
3	5 years	Short	Wide	Transverse	Successful	Graft fractured at ischial end, but united
4	4 years	Moderate	Wide	Slightly oblique	Successful	Hypertrophy of graft
5	1¼ years	Moderate	Wide	Transverse	Successful	Hypertrophy of graft
6	2 years	Moderate	Wide	Slightly oblique	Successful	Hypertrophy of graft
7	1¼ years	Long	Wide	Oblique	Failure	Graft fractured at ischial end
8	2 years	Short	Wide	Transverse	Successful	Hypertrophy of graft
9	2½ years	Long	Wide	Slightly oblique	Successful	
10	2½ years	Long	Thin	Slightly oblique	Successful	
11	10 months	Moderate	Wide	Transverse	Successful	Hypertrophy of graft
12	9 months	Short	Thin	Transverse	Successful	Hypertrophy of graft
13	1¾ years	Short	Wide	Transverse	Successful	Fracture at femoral end with reunion
14	3 months	Moderate	Thin	Slightly oblique	Successful	
15	10 months	Long	Thin	Transverse	Successful	
16	3 years	Moderate	Thin	Slightly oblique	Failure	Graft did not fuse at ischial end
17	1½ years	Moderate	Thin	Slightly oblique	Successful	
18	2 years	Short	Wide	Transverse	Successful	
19	1¾ years	Short	Thin	Oblique	Failure	Graft did not fuse at femoral end
20	1½ years	Moderate	Wide	Slightly oblique	Successful	
21	1¼ years	Moderate	Thin	Slightly oblique	Failure	Graft did not fuse at ischial end; fracture
22	2 years	Long	Thin	Oblique	Failure	Graft did not fuse at femoral end; fracture
23	1¼ years	Long	Thin	Transverse	Successful	Fracture at femoral end; united
24	2 years	Moderate	Thin	Slightly oblique	Successful	Fracture at ischial end with adduction of femur, and shortening of graft
25	3 years	Long	Thin	Oblique	Successful	Fracture at femoral end of the graft, bony resorption and shortening of graft, eventual union
26	1¾ years	Long	Thin	Very oblique	Successful	Non-fusion at femoral end. Union after screw-fixation
27	3 years	Long	Thin	Oblique	Failure	Non-fusion at ischial end
28	2 years	Moderate	Thin	Oblique	Failure	Non-fusion at ischial end
29	1¾ years	Moderate	Moderate	Oblique	Successful	

TABLE I—*continued*

ANALYSIS OF THIRTY-SIX CASES OF ISCHIO-FEMORAL ARTHRODESIS BY THE TRUMBLE TECHNIQUE

Case number	Follow-up period	Character of graft			Result	Comment
		Length	Width	Position		
30	3 years	Long	Thin	Oblique	Successful	Fracture at femoral end with reunion in adduction; abduction osteotomy
31	2 years	Moderate	Thin	Oblique	Failure	Non-fusion at ischial end
32	2 years	Long	Thin	Oblique	Failure	Fracture at femoral end; infection
33	1¼ years	Long	Thin	Oblique	Uncertain	Fracture at ischial end, with attenuation of the graft; union proceeding
34	1½ years	Long	Thin	Oblique	Failure	Fracture at femoral end and non-fusion at ischial end despite screw-fixation. Ilio-femoral arthrodesis done
35	4 months	Long	Thin	Oblique	Uncertain	Graft fractured at femoral end. Osteotomy performed later
36	4 months	Long	Thin	Oblique	Uncertain	

After operation, the patient is nursed in the plaster bed for three months, thereafter being allowed to begin walking with crutches.

CLINICAL MATERIAL

The results of thirty-six operations for ischio-femoral arthrodesis by the Trumble technique have been studied (Table I).

Method of assessing results—The rating of operations into "successful" or "failed" takes no account of the time needed for union; so long as firm bony union was demonstrable radiographically, no matter how long after operation, the case has been classified as successful. Only when non-union has been definitely established has the operation been regarded as unsuccessful.

Position and length of graft—Division into "oblique," "slightly oblique" and "transverse" position was made on the basis of the radiographs. A short graft was considered to be less than 2½ inches; a moderate length was taken as 2½ to 3½ inches; and a long graft was over 3½ inches. In width, a graft was classed as narrow when it measured less than half an inch across, and wide when it was more than half an inch.

Results—The results in the thirty-six cases were as follows: successful twenty-three cases; failed ten cases; uncertain three cases. In three of the cases rated as successful fusion did not proceed according to plan. In one, fusion was secured only after a screw had been inserted through the graft into the femur. In two the desired position of the hip was not maintained, a fracture of the femoral end of the graft having allowed adduction of the limb; in these cases the conditions at the time of the original operation were altered—both by shortening of the graft and by reduction of the obliquity of the entrance angle of the graft into its femoral bed. If these three cases had been omitted from the "successful" group on the grounds that the successful end-result was due to an alteration in the circumstances of the original operation, the proportion of failures would have been increased to 33 per cent. Illustrative radiographs and photographs are shown in Figures 4 to 11.

DISCUSSION

A study of the results showed that of the first fourteen operations only one was unsuccessful, whereas no less than nine of the later twenty-two operations failed. An

explanation must be sought to account for this difference.* In an attempt to correlate unsuccessful operation with the size and position of the graft the radiographs have been analysed in detail. It was found that the grafts could be classified into four groups: short and wide; long and narrow; short and narrow; long and wide; in each group the grafts were further graded according to their obliquity (Table II).

TABLE II

CLASSIFICATION OF GRAFTS BY SHAPE, SIZE AND POSITION, WITH RESULTS IN EACH GROUP

	Position	Complications	Fate
Group 1			
12 cases Grafts wide and short	Transverse . 8 Slightly oblique 3 Oblique . . 1	**Fracture:** Centre . 1 Femoral end 1 Ischial end . 1	All successful 5 grafts hypertrophied
Group 2			
13 cases Grafts thin and long	Transverse . 2 Slightly oblique 1 Oblique . . 10	**Fracture:** Femoral end 7 Ischial end . 1 **Non-fusion:** Ischial end . 2 Femoral end 1	Successful . . . 6 Failed (all with fracture of graft) . . . 4 Uncertain (all with fracture of graft) . . . 3
Group 3			
9 cases Grafts thin and short	Transverse . 1 Slightly oblique 5 Oblique . . 3	**Fracture:** Ischial end . 2 **Non-fusion:** Ischial end . 4 Femoral end 1	Successful . . . 4 Failed 5
Group 4			
2 cases Grafts long and wide	Slightly oblique 1 Oblique . . 1	**Fracture:** Ischial end . 1 (the oblique graft)	Successful . . . 1 Failed (oblique graft) . 1

In Trumble's (1937) series the grafts were placed transversely, according to the classification used in this series, and were short to moderate in length: all were wide grafts. Trumble suggested, however, that the grafts should be placed more obliquely than they had been, so that weight would be transmitted more directly through the graft from the ischium to the femur. In theory, this proposal is attractive, and it seems mechanically sound to endeavour, as nearly as possible, to reproduce the normal line of weight transmission as seen in the 125 degrees neck-shaft angle of the femur. As to the width of the graft, it was stated in Trumble's original article that it should be one-fifth as wide as it was long, and the results of the earlier cases reported by him proved that this ratio was adequate.

Comparison of the radiographs of the successful and unsuccessful cases suggests that the size and position of the graft have an important bearing on the result. Theoretically, the graft, when revascularised, may become hypertrophied in response to the task it has to perform (Figs. 5 and 6). But generally any change in the outline of the graft is only small. Should the graft be placed so that it is at a mechanical disadvantage, it will respond by fracture or resorption of bone (Figs. 9 and 11). This is especially likely to occur during the stage of initial rarefaction. In a similar way, non-fusion may occur at one or other end (Figs. 7, 8 and 10).

* Lack of practical experience demands that my approach to the subject should be theoretical. Therefore this review deals only with the functional mechanics of the graft, and does not take into account any technical difficulties encountered at operation—for example, the difficulty in an ankylosed hip of springing the graft into position, the mobility or otherwise of the joint at time of operation, or the effect of the graft on the tuberculous hip disease. It may be noted, however, that in many of the successful cases bony ankylosis of the hip followed.

The size of the graft. It was found that, of the four groups discussed, Group I, consisting of wide grafts, short or moderate in length, gave good results in every case (Table I). Complications, in the form of fracture, occurred in only one-quarter of the cases, but all

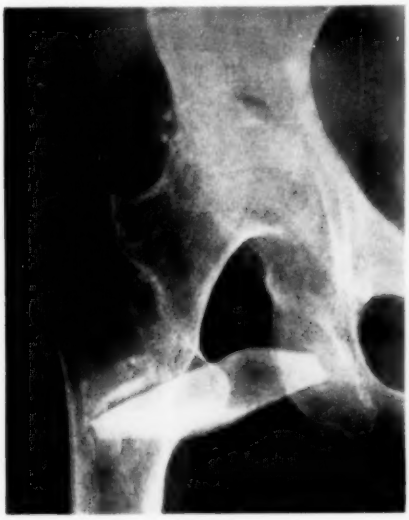

FIG. 4

FIG. 5

Figure 4.—Early post-operative radiograph of a transverse, short, wide graft. Figure 5.—Later radiograph showing modification of shape of graft from hypertrophy.

FIG. 6

FIG. 7

Figure 6.—Necropsy specimen of grafts shown in Figures 4 and 5. Considerable hypertrophy has occurred. Figure 7.—Necropsy specimen of an oblique graft. No hypertrophy and unsound union at femoral head.

subsequently united. In Group 2, consisting of thirteen long thin grafts, only six were successful. Ten of the cases were complicated by fracture or by failure of the graft to fuse at one or both ends. In Group 3, the successful cases were again less than half. This group

consisted of thin grafts, of short or moderate length. Seven of the nine cases showed one or more complications. The conclusion to be drawn about this factor—the size of the graft—is that the original description of "a stout free bone graft" should be interpreted

FIG. 8

FIG. 9

Figure 8—Radiograph showing established non-union at the femoral end of an oblique graft. Figure 9—Fracture and callus formation at centre of a long, thin transverse graft.

FIG. 10

FIG. 11

Figure 10—Attenuation and established non-union of the ischial end of a graft. Figure 11—Fracture near the ischial end of a graft. The femoral end has been fixed with a screw.

literally; there is no doubt that a short broad graft is more successful than a long thin one.

The position of the graft—The excellent results of Group I (Table II) were obtained, in most cases, by short wide grafts, placed either transversely or almost so. Only one graft was placed

obliquely. In the less successful Group 2, most of the grafts were placed obliquely. In Group 3 five of the nine grafts were slightly oblique in position, and of these three were successful. Of all the oblique grafts only one was successful without complications, and only four were ultimately successful. Two of these cases were complicated by resorption of the femoral end of the graft, the final result being a shorter and less oblique graft.

The conclusion is that the transverse or slightly oblique grafts are substantially more successful than those placed obliquely. Provided the graft is a stout one, the horizontal position of the graft gives a more certain fusion, and complications are far less frequent. Although a transverse lie of the graft does not duplicate the neck-shaft angle of the femur, it provides mechanically stronger union between the femur and the ischium. Substantial hypertrophy of a number of these transverse grafts shows that they are not at a mechanical disadvantage, and that they have blended into the lines of weight transmission of the affected hip. An example of hypertrophy and modification of shape to suit the stresses of the part is seen in Figures 4, 5 and 6, the specimen showing considerable new bone formation at the ends of the graft. In some cases the late radiographs showed that the re-ossified graft was slightly more oblique than it had been placed at operation. Undoubtedly this is in response to the functional requirements of the part. Most of the successful grafts showed some hypertrophy over a period, but in some the increase in size was tremendous, the graft more than doubling its original diameter.

Conversely, grafts placed obliquely appeared to be at a mechanical disadvantage, for fracture, non-fusion at one or other end (usually the femoral), and bony resorption of the graft at one end were frequent. An explanation for this may be found in the fact that in some of the more oblique grafts the graft-shaft angle was nearly 175 degrees. In general, the grafts classified as oblique exceeded the normal neck-shaft angle of the femur by at least 20 degrees. The slightly oblique position more nearly approximated the normal, while the transverse position was somewhat less than 125 degrees.

Conclusions.—This analysis suggests that a moderately short and wide graft, placed transversely or nearly transversely between the ischial tuberosity and the femur in the region of the lesser trochanter, is more satisfactory than thinner and longer grafts placed at any other angle, and that it is probably not wise to attempt to duplicate the normal neck-shaft angle of the femur with the graft. In a personal communication Trumble endorsed this view; and it is also supported by the results obtained in America by van Gorder (1949), who recorded ten cases of transversely placed grafts, all with successful results.

SUMMARY

1. Thirty-six cases of tuberculous hip disease treated by the Trumble type of extra-articular arthrodesis are reviewed.

2. The size and position of the graft, and the results and complications, are tabulated.

3. It is concluded that a short wide graft, placed almost horizontally between femur and ischium, gives the best results, and that a long obliquely placed graft is less satisfactory, and more liable to fracture or non-union.

I should like to thank Mr H. C. Trumble, Mr C. Hembrow, Mr E. Cato, and Mr J. B. Colquhoun for allowing me to publish the results of their cases. My thanks are also due to Dr V. Bristow for permission to use radiographs and clinical notes from the Austin Hospital, the source of all my material.

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THE OS PARACUNEIFORME

Some Observations on an Example Removed at Operation

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Rare accessory or inconstant bones of the foot are usually regarded by surgeons and radiologists as collectors' pieces, often of little more than academic interest. But from time to time such bones cause symptoms requiring surgical treatment.

The os paracuneiforme, first described by Dwight in 1902, is one of the least common of the accessory bones, and early descriptions of it are rather confused. Although it is always included in lists of accessory bones I have been able to trace only five recorded examples. Most of the descriptions are based on radiographic findings alone.

In 1924 Carlier described a case in which the bone was giving rise to symptoms and had to be removed. In the example now recorded the findings were almost exactly those of Carlier.

CASE REPORT

A man aged twenty-eight years presented himself complaining of pain of three months duration over a small bony swelling on the medial side of his right foot. The swelling had been present for as long as he could remember but had previously been symptomless. It was situated over the dorso-medial aspect of the medial cuneiform and was protected by an overlying bursa.

FIG. 1

Radiograph of right foot showing os paracuneiforme.

A small range of lateral movement was present, but it was impossible to produce any movement in the long axis of the foot. Radiographic examination showed a well-formed os paracuneiforme articulating with the medial aspect of the medial cuneiform (Fig. 1). The bone was partly accommodated in a hollow occupying the anterior two-thirds of the cuneiform, but projected beyond the general level of the medial border of the foot. No other abnormality was present. A radiograph of the left foot was normal. At operation, after removal of the small bursa, the bone was found to be partly incorporated in the substance of the tendon of the tibialis anterior and to be articulating with a facet on the medial surface of the medial cuneiform. It was dissected out of the tendon and the projecting postero-medial angle of the cuneiform was removed. The operation caused no disturbance of function except for temporary imbalance of muscle control from interference with the tendon of the tibialis anterior. The symptoms, which were due to pressure, were relieved.

DISCUSSION

Dwight's original description (1902) is of an ossicle lying in a hollow on the medial side of the foot between the navicular and medial cuneiform bones and this description is repeated by Holland (1928), Burman and Lapidus (1931) and Cameron (1923). On the other hand, Carlier's (1924) example, like the one now reported, is described as lying against the middle of the medial surface of the medial cuneiform, with which it articulated.

The present case is of interest from two aspects. First, it is unusual for an accessory bone to cause symptoms requiring surgical intervention, but examples occur from time to

time. A comprehensive account of functional disturbances produced by accessory bones is given by Burman and Lapidus (1931). Secondly, the relationship of the tendon of the tibialis anterior to the bone stimulates speculation whether the os paracuneiforme should be regarded as a true accessory bone, as a sesamoid, or perhaps as an example of an ununited traction epiphysis. The distinction between accessory bones, sesamoids and traction epiphyses is not clear cut. Wood Jones (1944) admits that it is no easy matter to define a sesamoid with any precision, and states that what is a free ossicle in a tendon in one animal may be a fixed skeletal element in another. Parsons (1904) drew attention to the fact that there is a similarity between the behaviour of traction epiphyses and sesamoid bodies and that the two structures occasionally change from one to the other. Similarly it may not always be possible to draw a rigid distinction between accessory bones and sesamoids.

In describing the specimen in which he found the paracuneiform Dwight (1902) stated: "At least a large part of this bone must have been under the tendon of the tibialis anterior," but this was speculation, not observation. Carlier's description is from the findings at operation, his actual words being: "Le tendon du jambier antérieur se passait sur son bord externe." In the present example the bone was almost completely incorporated in the tendon. This is in favour of regarding it as a sesamoid, and according to *Gray's Anatomy* one does occasionally appear late in life in the tendon of the tibialis anterior at this situation. But Parsons (1908) states: "When a sesamoid in a tendon is caused by the pressure of a bone into which the tendon is on its way to be attached, without the intervention of a fleshy belly, it fuses with that bone and a traction epiphysis results. When, on the other hand, the tendon is on its way to be attached to another bone, the sesamoid remains in that condition."

According to this conception, and in so far as the tibialis anterior is inserted into the base of the first metatarsal, the paracuneiform may be regarded as a sesamoid resulting from pressure of the tendon against the medial cuneiform. But at least half of it is inserted into the medial cuneiform, the bone against which the tendon and ossicle are playing. According to Parsons this would be in favour of classifying the paracuneiform as a traction epiphysis which had failed to unite. In support of this view the following suggestion is made as to the possible mode of development of the bone.

Since examination of the radiograph shows that it is not of traumatic or pathological origin its presence must be explained in terms of an anomaly of ossification. Normally the medial cuneiform is ossified from a single centre, but ossification of the prominent medial part of the bone from a secondary centre (analogous to the occasional secondary centre for the tuberosity of the navicular) is a possibility. Such a centre, lying in close relation to the tendon of the tibialis anterior, might fuse with the main part of the bone, giving rise to a true traction epiphysis; or, remaining separate, to an ossicle which might be regarded as a sesamoid body or an ununited traction epiphysis.

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INTERMETACARPAL FUSION

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Fusion of the metacarpal of the opposed thumb to that of the index finger may be applied to the hand grossly paralysed by anterior poliomyelitis when tendon transplants are not available or have failed, and to certain cases of spastic paralysis and trauma.

The disadvantages of the current operation are the difficulty of slotting a bone graft into the atrophic metacarpals of a paralytic hand and thereafter the necessity of maintaining accurate opposition by a plaster until fusion is sound.

The procedure to be described requires no more attention to detail than is necessary in the standard method but has the additional desirable feature that at the termination of operation the metacarpals are locked in the required position, avoiding the need for external means of immobilisation.

TECHNIQUE OF OPERATION

The metacarpal necks are exposed under pneumatic tourniquet through separate inch-long incisions placed on the dorso-medial aspect of the first metacarpal and the dorso-lateral aspect of the second. The periosteum of the first is incised lengthwise on the medial aspect and the second lengthwise on the palmar aspect; a tunnel through the soft tissues is established between the two. A piece of fibula of appropriate length is removed subperiosteally, with care to avoid splitting the cortex. A graft consisting of the full thickness of the iliac crest might prove equally suitable. One end is hollowed in order to bring the maximum area of bone in contact with the roughened metacarpal neck, and bevelled to fit the "V" of the gap between the metacarpals. The graft is then placed in the tunnel and the prepared end brought in contact with the neck of the first metacarpal. A fine pin or thick Kirschner wire is introduced at right angles to the long axis from the radial side and along the medullary cavity of the fibular graft until it appears at the open end, which is then nibbled to the correct length and inclination so that it fits firmly under compression in the gap between the necks. When the degree of opposition has been decided the pin is driven on through the second metacarpal neck so that the point appears on the radial side of the extensor tendons in such a manner that tension will be avoided when the adjacent skin incision is closed. The graft is now locked in position and the metacarpals immobilised in opposition. The periosteum is adjusted round the ends of the graft and the skin incisions closed. When the bandage has been applied, the protruding points of the pin are guarded by corks or other means (Figs. 1 and 2).

POST-OPERATIVE TREATMENT AND RESULTS

The theoretical objection to the technique described is the possibility of infection of the pin track. Limited experience suggests that with reasonable care the advantages greatly outweigh the risk. In the four cases in which the method has been used, the pin was removed after the arbitrary interval of eight weeks; all points of entrance and exit were dry. Thereafter protection in the form of a light plastic opposition splint was provided. The grafts were revascularised and united in twelve to sixteen weeks (Fig. 3).

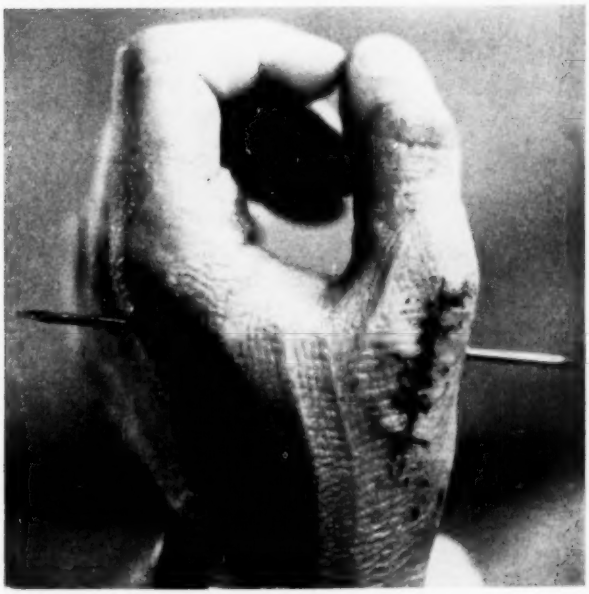

FIG. 1

Photograph showing position of transfixion pin immobilising the metacarpals and the graft.

FIG. 2

FIG. 3

Figure 2—Early post-operative radiograph. The pin holds the graft in place and at the same time immobilises the metacarpals in the required position of opposition. Figure 3—Twelve weeks after operation there was sound fusion of the graft. Pin removed at eight weeks.

THE USE OF WIRE RINGS FOR THE FIXATION OF SPINAL GRAFTS

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Fixation of bone grafts to the spinous processes of the vertebrae and especially to the posterior surface of the sacrum has always presented a difficult problem. Various methods have been used. The H-shaped graft is sometimes useful, but its rigid fixation depends upon the presence of well formed spinous processes. The spinous process of the sacrum is often poorly developed and in lumbo-sacral fusions fixation of the grafts by soft stainless steel wire rings has been found most useful. Indeed the rings give such excellent fixation that I have used them elsewhere in preference to the H-shaped graft, and they have the additional advantage that any number of vertebrae can be fused.

Technique—The method resembles the insertion of a ring into a pig's nose; in fact the pliers used to hold and close the rings are identical. The rings (Fig. 1) are made of non-toxic stainless steel and it is advisable to have them opened widely so that the greatest possible amount of lamina can be included.

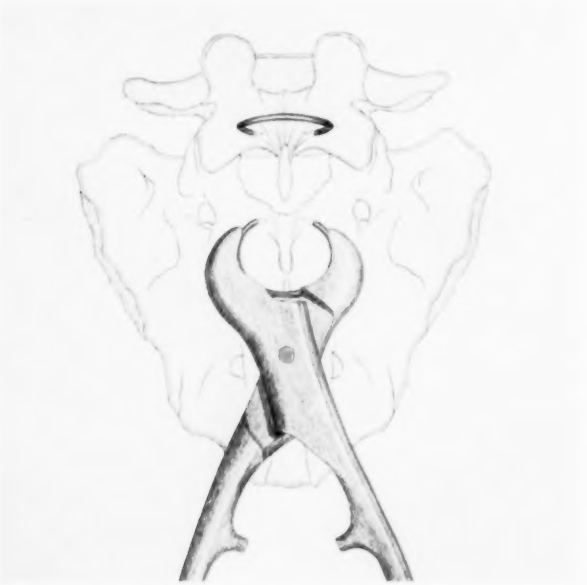

Fig. 1

Showing the steel rings and the method of insertion.

The bases of the spinous processes and the adjacent parts of the laminae must be well prepared so that patches of subcortical bone are exposed. If interfacetal bone pegging is also employed, the necessary drilling and pegging are carried out at this stage. The rings are held in the special pliers (Fig. 1) and applied to the posterior surface of the laminae. By closing the pliers slightly the ring points are made to engage in the bone, but they should not be fully squeezed home until after the bone grafts have been placed within them.

The grafts, cut from the tibia, are long thin splinters, each the thickness of a match stick and of appropriate length for the area to be fused. The whole of the space within the rings as well as that between the spinous processes is tightly packed with the grafts (Fig. 2). Firm pressure with the pliers closes the rings and compresses the grafts against the spinous processes. In this way firm fixation is obtained (Fig. 3).

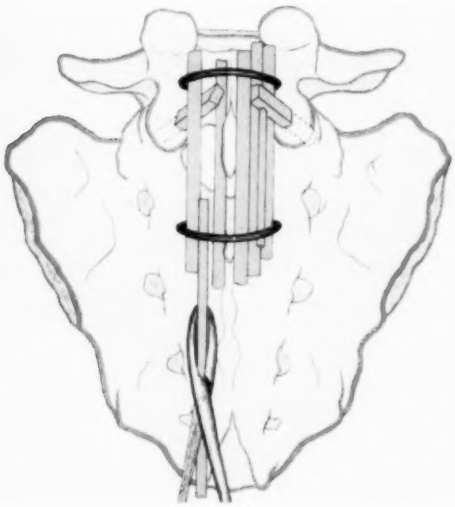

FIG. 2

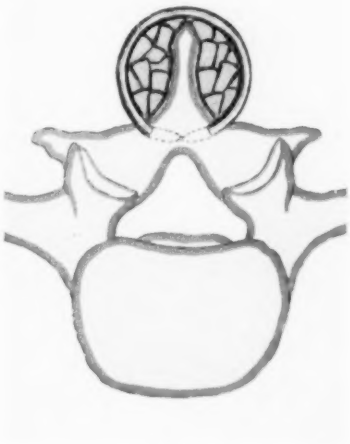

FIG. 3

Figure 2.—Bone pegs have been driven across the facet joints. Bone grafts are being inserted within the steel rings. Figure 3.—The grafts are compressed against the spinous processes by closing the rings.

Post-operative treatment.—If interfacetal bone pegging and ring fixation of the interspinous grafts are employed, a plaster bed is not considered necessary except in tuberculous disease. A plaster corset is used instead. The plaster corset is made a day or so before the operation, split down the front, and removed. Straps and buckles are applied to it so that it can be put on the patient over the dressings at the conclusion of the operation.

The patient is allowed up in the plaster after six weeks. Later the plaster may be replaced by a light lumbo-sacral support, which must be retained until at least six months from the time of operation.

The rings and pliers for holding and compressing them are made by Messrs Down Bros. and Mayer & Phelps Ltd., 32-34 New Cavendish Street, London, W. 1.

NEUROFIBROMA ERODING THE CARPUS

Report of a Case

T. B. Whiston, Falkirk, Stirlingshire, Scotland

Although the clinical manifestations of neurofibromatosis (von Recklinghausen's disease) are familiar to most, particularly the cutaneous lesions, the incidence of skeletal change is only 7 per cent. Brooks and Lehman (1924) studied seven cases with radiographic changes in the bones. They noted the occurrence of subperiosteal and cortical cysts and, in three cases, increase in bone length with elephantiasis neuromatosa in the affected limb. Their findings, according to Weber (1930), signified involvement of the periosteal nerve plexus. Weber (1930) described the post-mortem findings in the tibia of a woman with typical neurofibromata in the skin (molluscum fibrosum), who had died from a cerebral abscess. The tibia was covered with a thickened mass of periosteum, the cell pattern of which resembled that of one of the skin tumours. The cortex had not been penetrated. Mackenzie (1950), commenting on the radiographic changes in a man aged twenty-one with extensive neurofibromatosis of the skin, found a thoracic scoliosis with hemivertebra, cortical erosion and pitting, cyst-like areas, and irregular deposition of non-systematised new bone which lacked the normal trabecular pattern.

Fig. 1

Cystic changes and erosion of carpal bones at ulnar side of wrist. Styloid process of ulna and base of fifth metacarpal are also involved.

CASE REPORT

A woman aged twenty-two complained of intermittent pain in the right wrist, with swelling, for three years. She attributed the condition to a fall but no bony damage had been suspected at the time, and the wrist had been treated only by strapping. *On examination* there was a puffy diffuse swelling on the back of the right wrist near the ulnar border. There was no tenderness on palpation, and movements were satisfactory in range, although slight radial deviation was noted. The local temperature was not raised, and no motor or sensory changes were observed. There were multiple skin tumours and "café au lait" spots typical of neurofibromatosis on the chest, back and arms.

Radiographs showed cystic changes in the bones of the right carpus, especially on the ulnar side, and some erosion of bone (Fig. 1). The joint spaces were clear. The lung fields were normal. *Investigations*—The Wassermann reaction was negative, and the blood sedimentation rate was normal. The diagnosis of neurofibromatosis with skeletal involvement seemed probable, and it was confirmed by biopsy of a skin tumour from the right arm and of bone from the hamate and pisiform. Immobilisation of the wrist in plaster for several weeks, with physiotherapy thereafter, brought considerable relief of symptoms, and the disability was insufficient to justify further treatment. *Histology of biopsy specimens*—Sections from the skin showed typical neurofibromatous tissue occupying the deeper layers of the dermis. Sections from the bones showed that bone lamellae were being eroded and replaced by neurofibromatous tissue which closely resembled the skin lesion. The loose texture of the

newly formed tissue adjacent to the bone stood out in sharp contrast to the dense older tissue below (Fig. 2). The high-power view (Fig. 3) showed the loose "tangled" cellular pattern, which resembled that of the skin lesion. "Palisading" was evident in some areas.

DISCUSSION

Skeletal changes in neurofibromatosis include increase of length, erosion of bone, cyst-like areas, and joint changes. Increase of bone length is associated with hyperaemia as in elephantiasis neuromatosa. Erosion of bone may result from direct pressure of contiguous soft tissue tumours. Periosteal nerve involvement may produce erosive defects of the cortex, deformity, irregular sclerosis, and subperiosteal or cortical cysts. The present case belongs

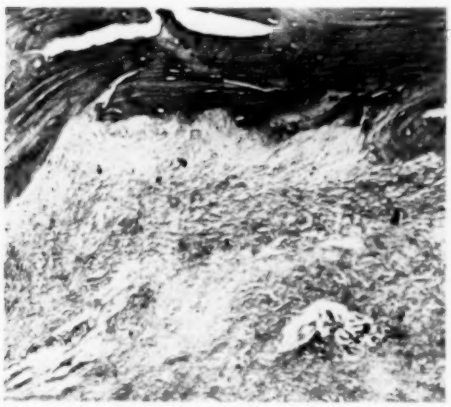

FIG. 2

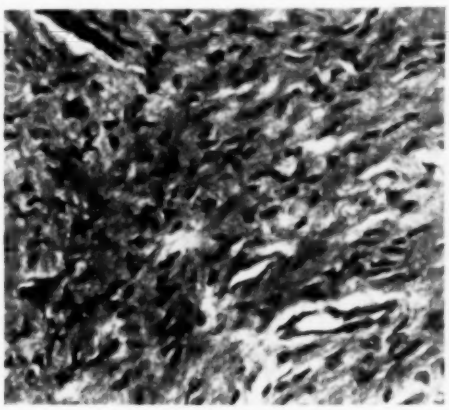

FIG. 3

Sections from carpus. Figure 2—Low power view, showing erosion of lamellae by invading tissue. The newly formed loose tissue above contrasts with dense older tissue below. Figure 3—High power view. Note loose "tangled" cellular pattern. "Palisading" is seen in left central and upper part.

to this category. Cyst-like areas within bone were considered by Stöhr (1928) to arise from tumours of the nerve fibres coursing through the Haversian canals and nutrient foramina. Recently Bingold (1952) has mentioned specific joint changes. A fundamental genetic defect is considered by Lichtenstein and Jaffe (1942) to be the underlying cause.

I am indebted to Mr A. J. Innes, and to Dr J. Park, Medical Superintendent of the Falkirk Royal Infirmary, for permission to publish this case; to Dr R. Rankine for his aid with the histological examinations; to Dr W. Cockburn for interpreting the radiographs; and to Mr J. N. J. Hartley for helpful criticism and advice.

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BILATERAL GLENOID HYPOPLASIA

Report of Five Cases

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The five patients under consideration, all of whom were seen within three years, had in common a bilateral defect of the glenoid articular surface of the scapula accompanied by flattening of the humeral head. In some there were associated abnormalities in the axial skeleton. Disability was marked in only two cases.

Reports of only a few similar cases have been found in the literature. Giongo (1927) and Heupke (1928) reported "glenoid dysplasia and clavicular spurs." Brailsford (1944) mentioned those and described three further patients (two women and one girl of nine years), all with bilateral defects of the glenoid, webbing of the axillae and limitation of abduction; he regarded them as congenital deformities, and mentioned the possibility of concomitant spurring of the clavicles and tendency to humerus varus. Scaglietti (1938) and Lucas and Gill (1947) discussed cases of humerus varus with secondary glenoid hypoplasia. Their cases were ascribed to birth injuries with epiphysial separation and later moulding. Scaglietti noted that bilateral defects occurred after breech delivery, whereas unilateral deformity usually followed normal vertex birth. Andreasen (1948) described congenital defects of the humeral heads in two adults. His cases were similar to the cases described here, but the defect of the head was much more marked and the glenoid surface was decidedly convex.

CASE REPORTS

Case 1—Schoolboy aged fifteen years. He stated that he had never been able to lift his arms above shoulder level. There was no history of maternal illness in pregnancy, birth was normal, no relevant childhood illness or injury was known and no other member of the family was similarly

Fig. 1

Case 1—Showing shoulders abducted to fullest extent.

affected. Clinically, apart from moderate underdevelopment of the deltoid and pectoral muscles, the outward appearance was normal. Shoulder movements, however, showed abduction in the scapular plane to only 90 degrees, even with the arms in lateral rotation (Fig. 1). The thoraco-scapular movement was normal, the restriction of abduction being entirely in the scapulo-humeral joint. Rotation was free. Hip and cervical spine movements were full. No other congenital abnormalities were noted.

Radiographic examination—On each side there was a defect of the inferior angle of the articular surface of the glenoid (Figs. 2 to 5). The superior epiphysis was present but ununited. There was slight flattening of the medial part of the upper humeral epiphysis. The lateral end of each clavicle showed a curious hooked appearance and a bony "knob" protruded from its inferior aspect at the site of insertion of the conoid and trapezoid ligaments (*cf.* Brailsford 1944). The coracoid processes were large and prominent. No abnormality was detected in the cervical spine or pelvis.

FIG. 2

FIG. 3

Case 1—Right and left shoulders with arms by the side.

FIG. 4

FIG. 5

Case 1—Right and left shoulders with arms abducted to fullest extent.

Case 2—Man aged twenty years. Complained of inability to raise either arm above shoulder level from infancy. He was keen on farming but the disability compelled him to take up an office job. When seven months pregnant the mother had suffered from protracted vomiting. Delivery was at full term. The forceps was used for a normal vertex presentation. There were no childhood incidents and the family history was negative. In general the patient was well developed, but stood with a moderate thoracic kyphosis and slight elevation of the left shoulder. There was also a

"funnel chest" deformity. *Shoulder movements*—Rotation and forward flexion were normal. Abduction both in medial and in lateral rotation was markedly limited (Fig. 6). When abduction was attempted the humeral heads seemed to subluxate backwards on the glenoid. Rotation at the left hip was slightly limited but there was no obvious asymmetry of the lower limbs.
Radiographic examination—On each side there was hypoplasia of the glenoid fossa affecting mostly its inferior angle; the articular surface was almost vertical and merged into the axillary border of the scapula (Fig. 7). In the axial view the posterior part of the glenoid especially was poorly

FIG. 6
Case 2—Showing shoulders abducted to fullest extent.

FIG. 7

FIG. 8
Case 2—Left shoulder seen in antero-posterior projection (Fig. 7) and in axial view (Fig. 8). The right shoulder was similar.

developed (Fig. 8) (hence the clinical finding of backward shift of the humeral heads in abduction). The coracoid process was large, and the articular surface of the humeral head was flattened. The only associated abnormalities detected were wedging of the C.7 vertebral body and spina bifida of the T.1 vertebra. The hips appeared normal.
Case 3—Man aged forty years. Joiner. He had noticed no disability of the limbs except that from childhood the left arm had been slightly weaker than the right. He was first seen as a casualty after sustaining a fracture of the left glenoid fossa in a fall, and it was thus that his abnormal

FIG. 9
Case 3.—Right shoulder.

FIG. 10
Case 3.—Left shoulder.

limbs were discovered. Clinically there was obvious hypoplasta of the left arm and shoulder girdle. The left lower limb was three-quarters of an inch shorter than the right owing to congenitally short femur. There was asymmetry of the chest from flattening of the thoracic cage on the left. Movements of the right shoulder were normal and, although those of the left shoulder were restricted at that time because of the injury, later examination showed practically a full range of abduction. There were no neurological signs.

Radiographic examination.—On each side there was a defect of the glenoid fossa affecting predominantly the inferior half of the articular surface, as in the previous cases (Figs. 9 and 10). (There was a recent fracture on the left side.) Each humeral head was of oval shape. There was a small bony knob on the inferior aspect of each clavicle like those described in Case 1. There were bilateral cervical ribs, but no congenital abnormality was noted in the thoracic cage or hip joints.

Case 4.—Woman aged forty-five years. Had never had trouble with her shoulders until her first attendance two years ago. At that time she was suffering from mild periarthritis of the left shoulder as the result of a fall. When examined recently recovery from this was complete. She had been told that she had been born "seven weeks too soon," but otherwise pregnancy and labour had been normal. Her mother had suffered from "a bad hip" since childhood; otherwise the family history was clear. On examination the patient was asthenic but no obvious locomotor defect was present. The extremes of shoulder abduction and medial rotation, however, were limited on both sides.

Radiographic examination.—In each shoulder there was hypoplasia of the glenoid articular surface (Fig. 11) like that found in Case 2. The humeral heads were only slightly abnormal. There was a cervical rib on the left side, and on the right an ossicle was noted near the transverse process of the C 7 vertebra.

FIG. 11
Case 4.—Left shoulder.

Case 5—Man aged forty-six years. Miner. Complained of stiffness of the right shoulder after an injury ten years previously. Past history and family history were negative. Apart from moderate wasting of the right shoulder girdle and disturbed scapulo-humeral rhythm from periarthritis, physical examination was negative. The left shoulder was normal in appearance and function.

Radiographic examination—In each shoulder there was a glenoid defect like that found in the previous cases. On the right side there was slight lipping of the articular margin; otherwise the humeral heads were normal, and no clavicular spurs were noted. No radiographs of the spine or hips were available.

DISCUSSION

The cases considered here have first to be differentiated from similar acquired deformities of the shoulder. Thus Scaglietti's (1938) description of bilateral humerus varus with epiphysial hypoplasia of the glenoid was ascribed to birth injury to the upper humeral epiphysis. There was an associated irregular sclerosis of the middle third of the clavicle with accentuation of its normal S-shaped curve. Clinically the arms were medially rotated and slightly abducted.

Other recognised causes of humerus varus produce transient softening of the humeral head in early life: rickets and Barlow's disease are examples. Unilateral deformity may arise from injury to the epiphysis in the formative years between five and twelve, with consequent osteochondritis. Fairbank's (1947) multiple epiphysial dysplasia can give a similar picture, but changes are present in other joints such as the hips. Erb's palsy, producing secondary disuse atrophy of bone from muscular weakness, and the muscular dystrophies (Ashby *et al.* 1951) are sometimes associated with hypoplastic humeral heads and glenoid cavities.

In contrast, the present cases are considered to be congenital in nature. This view is supported by the presence in some of the cases of other skeletal abnormalities such as cervical spina bifida and hemivertebra, cervical ribs, clavicular spurs and hemiatrophy. It is unlikely that all these are coincidental. In no case is there evidence of post-natal or birth injury and no soft tissue or nervous changes were observed (the recent injuries are discounted).

Radiological studies have shown that the normal glenoid is made up of three components (Brailsford 1944). Its floor is included in the main scapular body which ossifies at approximately the eighth week of intra-uterine life. The apophysis which appears at the tenth year goes to form the upper ring of the glenoid and base of the coracoid process. Finally, the inferior segment of the glenoid is derived from a centre appearing at about thirteen years. This serves to deepen the articular surface and produce a well defined inferior articular margin. It is to be noted that the precartilage for the centre is normally already well established in utero. Rarely a separate ossicle is seen at the superior and inferior angles of the glenoid in children of about twelve years. The humeral head is formed from a medial epiphysial centre ossifying at six months, a lateral one at two years and an anterior one for the lesser tuberosity at five years.

A simple explanation of the abnormality of the glenoid in the present cases is that the precartilage of the inferior apophysis failed to develop. But this does not explain the underlying embryological processes involved. Much of the work done in this field has been on embryo chicks, the experiments involving ablation of embryonic tissue. No parallel process takes place in the developing human foetus, but certain general conclusions have been reached. These are based mainly on the work of Murray (1926) and of Fell and Canti (1934) on the development of isolated limb buds of chick embryos implanted on chorio-allantoic membrane. 1) Early joint formation is not dependent on the presence of muscle, nerve or vascular tissue. It does, however, depend on intrinsic predetermined factors—the so-called inherent mosaic. 2) Some form of joint will appear even if the presumptive joint region has been ablated (not applicable in man). 3) The shape of such a joint will depend on the amount of tissue removed or destroyed and the stage of development of the blastoma at the time of ablation. 4) In

normal joints the precartilage determines the future shape of the bone laid down. 5) In post-natal life extrinsic factors such as muscle pull or trauma influence joint shape to some extent. The full story of early bone and joint development still awaits clarification. It would therefore be presumptuous to be too categorical about the precise congenital factors involved in the causation of the shoulder defects described.

SUMMARY

1. Five cases of bilateral glenoid hypoplasia are described. Flattening of the humeral heads and sometimes other skeletal abnormalities coexisted.
2. The condition is considered to be congenital.
3. The differential diagnosis and etiology are discussed.

I should like to thank Mr Norman W. Roberts and Mr Robert Roaf for their helpful criticism and permission to report these cases. I am indebted also to the staff of the photographic department of Liverpool University for the illustrations.

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HUMERUS VARUS

Report of a Case Treated by Excision of the Acromion

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Congenital anomalies of the head of the humerus without any other developmental abnormality are rare. Köhler (1935) described the radiological criteria for the diagnosis of

Fig. 1

Fig. 2

Figure 1—Pre-operative range of abduction. Figure 2—Pre-operative radiograph showing impaction between tuberosity and acromion.

humerus varus as reduction of the head-shaft angle below 140 degrees, elevation of the greater tuberosity above the level of the superior margin of the neck, and reduction of the distance between the articular surface of the head and the lateral cortex of the humerus.

CASE REPORT

The patient, who was eighteen years of age when she first presented herself, complained of aching in the right shoulder and progressive limitation of abduction for five years. There was no history of injury. She was unable to abduct the arm actively more than 80 degrees, and lateral rotation was considerably limited; scapular movement was responsible for all but 20 degrees of her range. The other joints were normal. On examination under anaesthesia only a few degrees of added movement could be obtained.

Figure 1 shows the degree to which abduction was limited before operation and Figure 2 the radiographic appearance at approximately 45 degrees of abduction. It was at this point that pain was felt. The anomaly is well shown in this radiograph and the impaction of the enlarged tuberosity against the acromion can be appreciated. It will be noticed, too, that the shaft of the bone is narrower than normal, but there was no shortening of the upper limb which has been reported in association with the diminished neck-shaft angle.

Treatment—The acromion, against which the tuberosity appeared to impinge, was excised as far as the acromio-clavicular joint; this enabled the arm to be brought into almost full abduction, the last few degrees being limited by secondary shortening of the pectoralis major.

Progress—After operation she rapidly gained control of the increased range of abduction (Fig. 4). Lateral rotation was restored to normal. Figure 3 indicates that her present restriction at extreme range is due to contact between the tuberosity and the tip of the clavicle.

FIG. 3

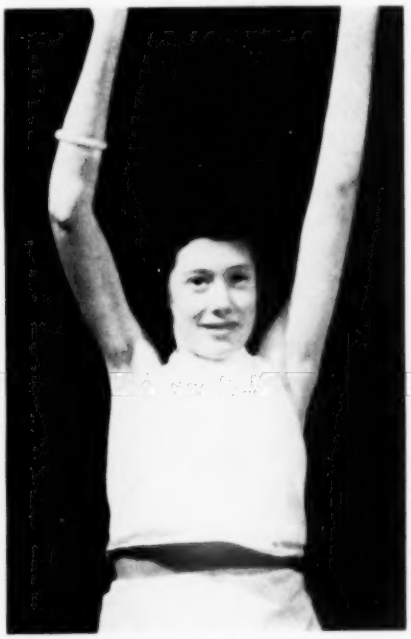

FIG. 4

Figure 3—Post-operative radiograph showing arm in greatest abduction. Figure 4—Post-operative range of abduction.

Comment—The simplicity of this procedure contrasts favourably with the more elaborate abduction osteotomies which have been carried out for the relief of this condition (Lucas and Gill 1947).

I am grateful to Mr B. H. Burns and Mr R. H. Young for allowing me to treat this patient and submit this report. I am also indebted to Mr K. Chant for the photographs.

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ANEURYSM OF THE POPLITEAL ARTERY FROM PERFORATION BY A CANCELLOUS EXOSTOSIS OF THE FEMUR

Report of a Case

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Cancellous exostoses are common but perforation of an artery by such an exostosis must be of great rarity. That such an event should have led to the formation of a large saccular aneurysm which proved to be reparable by endo-aneurysmorrhaphy is sufficiently remarkable to be worthy of record.

CASE REPORT

A Sinhalese man aged twenty-two years was admitted to the General Hospital, Colombo, on account of a painful swelling behind the left knee which had been noted for seventeen

FIG. 1

Diagram depicting principal physical signs of the case.

days. There had been no injury. The swelling was soft, fluctuant, warm and tender; the overlying skin was normal in texture; and the margins of the swelling could not be defined clearly. The swelling did not pulsate. The foot and the leg were warm but pulses could not be felt in the dorsalis pedis or posterior tibial arteries. On the medial aspect of the thigh in front of the swelling was a nodular mass of bone arising from the lower end of the femur. Similar nodular masses of bone were seen and felt arising from the lower end of the right femur, from the upper ends of both tibiae, the upper ends of both humeri and the lower ends of both radii; there was deformity at the wrists but the patient had little disability from these exostoses. There was no family history of similar bone tumours or deformities.

The ovoid swelling behind the left knee was recognised as an aneurysm of the popliteal artery and an operation was performed under spinal anaesthesia. An incision four inches long was made on the medial surface of the thigh, the deep fascia divided, the sartorius muscle retracted backwards, and the bursa capping the bony mass opened, thus exposing a large cartilage-capped exostosis with a pedicle sloping towards the lower end of the femoral shaft. The exostosis was removed. A large ovoid aneurysm of the popliteal artery was then exposed, lying behind the adductor magnus muscle and filling the popliteal space. The popliteal artery

was traced through the opening in the adductor magnus muscle to the upper pole of the aneurysm which was exposed through a second, midline, incision. The medial and lateral popliteal nerves coursed over the posterior surface of the aneurysm. At the lower pole the popliteal artery was seen passing deep under the two heads of the gastrocnemius muscle. Two temporary tape ligatures were placed at the upper and lower poles of the aneurysm, which was opened by a vertical incision on its medial surface. It contained dark red clot, and when this had been wiped away there was violent haemorrhage which was arrested by

FIG. 2
Radiographs of left knee joint.

digital pressure. There was a small hole on the front wall of the vessel directly opposite the base of the pedicle of the exostosis. Two small rubber-shod clamps were placed above and below the hole, which just admitted the tip of a finger, and it was closed by fine cotton thread sutures soaked in vaseline. The patient made a good recovery. Pulses did not return in the dorsalis pedis or posterior tibial arteries but the foot remained warm, and although slight oedema of the foot developed after four days this did not persist and the patient left hospital after two months, walking with ease.

POPLITEAL ANEURYSM AFTER LATERAL MENISCECTOMY

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The intimate relation between the lateral inferior genicular artery and the posterior capsule of the knee joint puts the artery in hazard during operative removal of the lateral cartilage. Although damage to the artery at operation, with the subsequent development of an aneurysm in the popliteal fossa, appears to be a recognised complication of lateral meniscectomy, few cases have ever been described in surgical literature. Elkin (1948) described one case and Fairbank and Jamieson (1951) have described two cases in which the artery was damaged while passing within the joint capsule. In the case to be described the lesion assumed the appearance of a saccular aneurysm of the popliteal artery although it arose, in the first instance, from the lateral inferior genicular artery. The purpose of this paper is to describe the production of such an aneurysm and to discuss the treatment.

CASE REPORT

A man of twenty-seven years was admitted with the typical features of a lesion of the lateral semilunar cartilage. The cartilage was excised through a straight incision at the lateral side of the patella, a tourniquet being used. There were two tears of the free margin

Fig. 1

Fig. 2

The antero-posterior angiogram (Fig. 1) shows the displacement of the popliteal artery. The lateral view (Fig. 2) shows the stump of the lateral inferior genicular artery and the ill-defined shadow made by the contrast material in the aneurysmal sac posterior to it.

of the cartilage. Difficulty was experienced in removing the posterior half. After the operation a pressure bandage was applied, but when the tourniquet was released bright red blood seeped rapidly through the dressings. The dressings were removed and a quantity of bright blood was expressed from the wound. It was observed that the joint itself was not distended. Fresh dressings were applied with firmer pressure. These dressings also became stained, but further observation indicated that the bleeding was controlled and the patient was returned to the ward. Convalescence was uneventful until the tenth day after operation, when the dressing was removed to reveal a pulsating swelling on the posterior aspect of the knee. Six days later the swelling had become rounded and more defined, although it could not be distinguished from the lateral head of the gastrocnemius muscle. Compression of the femoral artery in the upper thigh arrested the pulsation. The distal part of the limb showed little change. The veins over the dorsum of the foot became congested when the limb was dependent, but the colour of the foot was satisfactory and good pulsation was felt in the posterior tibial and dorsalis pedis arteries.

Angiography (Dr K. Jamieson)—The injection was made into the femoral artery at the lower end of the femoral canal, while the femoral artery was compressed proximally. The popliteal artery was shown to be displaced medially and, opposite the joint space, there was a constriction of its lumen (Figs. 1 and 2). The constriction was entirely in the transverse diameter of the vessel. The findings suggested that the popliteal artery was stretched over an aneurysm on its lateral aspect. The communication with the aneurysm was not demonstrated, because the amount of opaque fluid which passed into the aneurysmal sac was inadequate for contrast, the peripheral part of the aneurysm being ill defined. But it was possible to show the proximal part of the inferior lateral genicular artery, which appeared as a stump-like projection four millimetres long at the level of the joint space (Fig. 2). There was a good flow of blood to the distal part of the limb. From the evidence obtained it seemed that the aneurysm originated from the inferior lateral genicular artery close to its origin from the popliteal artery, and was distorting but not obstructing the popliteal vessels. Retrograde angiography immediately before operation upon the aneurysm did not provide any further information.

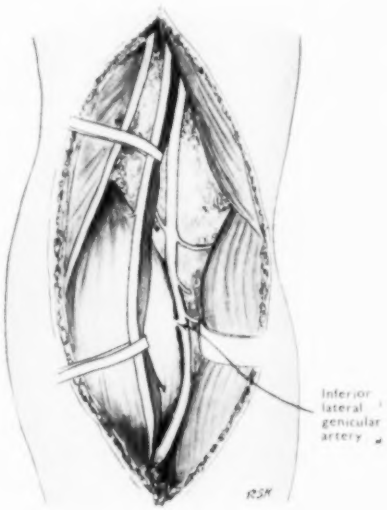

FIG. 3

Sketch showing the relations of the aneurysmal sac to the contents of the popliteal fossa.

Operation—The popliteal fossa was exposed and the aneurysm defined. It lay on the lateral aspect of the popliteal artery, to which it was adherent. The stump of the inferior lateral genicular artery was found to be completely taken up in the wall of the aneurysm and it was impracticable to define a neck between the popliteal artery and aneurysmal sac without risk of tearing the main vessel (Fig. 3). Proximal ligation of the entering vessel being thus impossible, the aneurysmal sac was opened and its proximal orifice occluded by oversewing with fine silk sutures. A second layer of silk sutures brought the surrounding part of the wall over this suture line and finally the walls of the aneurysm were brought together with catgut sutures. The peripheral circulation remained normal and the post-operative course was uneventful.

DISCUSSION

Anatomy—The exact relationship of the inferior lateral genicular artery to the posterior part of the joint capsule varies slightly, but this variation is sufficient to make the vessel vulnerable during operation in one subject whereas, in another, damage to the vessel is unlikely because the vessel lies below the level of the joint space. In our patient the vessel arose from the popliteal artery immediately behind the posterior attachment of the lateral cartilage and a similar relationship was observed in two of three cadavers examined.

Technique of meniscectomy—It has always been suspected that the use of Smillie's cartilage knife is fraught with danger. On one other occasion the knife was felt to pass through the capsule posteriorly, fortunately without any serious result. The knife was not felt to pierce the capsule in the present case and it is not clear at what stage the injury to the artery took place.

Angiography—The angiogram was valuable in determining the type of lesion, but the poor contrast within the aneurysmal sac was disappointing. More experience and a better radiographic technique might have led to better results when the retrograde filling of the popliteal artery from the aneurysm was attempted.

Treatment—The critical point to be determined is the point of origin of the aneurysm and its relation to the popliteal artery. If the sac arises directly from the popliteal artery there is a serious risk of occlusion of the artery when the aneurysmal sac is obliterated, and in such a case it would be wise to delay operation until the collateral circulation could be established, and a coincident lumbar sympathectomy should be undertaken, if necessary, to tide the patient over the early period after occlusion of the popliteal artery.

If the aneurysm is shown to arise from the inferior lateral genicular branch, the ease with which it can be dealt with will depend upon the length of the proximal part of the branch and the secondary changes that have taken place in the wall of the aneurysm. In such cases early operation is likely to permit easier and more satisfactory operative repair.

Operative technique—Although ligation of the entering vessel and excision of the sac may be considered the method of choice in dealing with saccular aneurysm, whether this be of the false or true variety, the ease with which a satisfactory result may be obtained by endo-aneurysmorrhaphy reinforces the view recently expressed by Rogers (1951), who described three cases in which this method was used. In accessible situations like the popliteal space, where dissection can be readily carried out and vessels controlled either by arterial clamps or digital pressure, it is easily practicable to open the sac and occlude the arterial openings on the inside with little loss of blood.

SUMMARY

1. A case of traumatic aneurysm in the popliteal fossa after a lateral meniscectomy is described.

2. Relevant factors in the surgical anatomy of the inferior genicular artery are discussed.

3. The value and limitations of angiography of the popliteal artery are considered.

4. Treatment is governed by the degree of involvement of the popliteal artery. In the case described cure of the aneurysm was obtained by endo-aneurysmorrhaphy.

We are grateful to the Medical Superintendent of the Repatriation General Hospital, Heidelberg, Victoria, for permission to report this case.

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XANTHOGRANULOMATOUS DISEASE OF BONE WITH POLYARTHRITIS

Report of Two Cases

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The cases to be described present, as far as we can tell from the literature, a unique combination of pathological changes, namely: 1) rheumatoid polyarthritis; 2) advanced cystic changes of long bones showing histologically a xanthogranulomatous type of lesion; and 3) in one case, enormous cystic swellings of the limbs with a histological resemblance to the bone cysts.

CASE REPORTS

Case 1—Man aged fifty-nine years. History of pain and swelling of the left knee in 1938. Available records indicate that there was a large effusion associated with an extensive bursa in the popliteal space. Treatment was by excision of the bursa and synovectomy. The bursa and the joint both contained thick fibrinous fluid. After operation the knee made good progress and he returned to work. Later he noticed increasing pain and stiffness in the elbows, wrists, hands and fingers, as well as in both knees. He was first seen by one of us (G. N. G.) eleven years after the onset. His disability had increased rapidly during the previous year and during the last few months he had been confined to bed.

Clinical findings—He looked older than fifty-nine. He was poorly nourished and the muscles generally were wasted. Lymph nodes were palpable in axillae and groins but not elsewhere. The abdominal and thoracic organs showed no abnormality. Arthritis involved both shoulders, elbows, wrists, fingers, hips, knees, and tarsal and metatarso-phalangeal joints. The wrists and finger joints showed deformities characteristic of rheumatoid arthritis, with ulnar deviation of the metacarpo-phalangeal joints. There was an enormous cystic mass over the extensor surface of the right forearm in its upper three-quarters. This spread round the forearm, especially on the outer side, but did not envelop it completely. The cyst was in the main adherent to the skin and was not tense. It appeared unilocular and did not obviously communicate with the elbow joint. There were several small subcutaneous nodules in the right elbow region, flattened and about the size of a split pea, but these were not found elsewhere. A large cystic mass occupied the right popliteal space and extended widely into the thigh and calf.

The cyst of the right forearm was removed. It was found to be closely adherent to the skin and burrowed deeply among the muscles. Dissection was difficult owing to the lack of a definite cyst wall, which in places was formed by the surrounding tissues themselves. The greater part was composed of a single cavity but near the elbow there was some loculation and a small communication with the joint. The cavity was lined by a thick friable membrane of a dirty yellow colour; it contained a thick light brown fluid with much semi-solid yellow necrotic debris. The cyst lay directly on the posterior surface of the shaft of the ulna and there was a definite opening, about half an inch in diameter, in the cortex by which the cyst cavity communicated with the medulla of the bone. Sufficient cortical bone was removed to show the bone structure. The cortex was thin, like parchment, and little of the normal cancellous bone was seen. Instead, a few fine trabeculae crossed the medullary cavity transversely, dividing it incompletely into compartments. The lining and contents of the bone cavity were like those of the cyst. Two small subcutaneous nodules from the inner aspect of the elbow were removed and found to contain normal fatty tissue.

The large semi-membranosus bursa was later removed. It showed a rather more definite and friable capsule than the cyst of the forearm. Its contents were a thick yellow "pea soup" material containing many yellow fragments of fibrin. The cyst communicated with the knee joint by an opening large enough to admit the tip of the index finger. Brown hypertrophied synovial membrane was removed from the knee joint through this opening.

Radiographic examination—The elbows, wrists, hands, knees, and mid-tarsal joints showed changes of rheumatoid arthritis, with loss of joint space and circular erosions of bone adjacent to the articular surfaces of some of the joints. The most striking feature was the condition of the juxta-articular bone of the elbows and knees, and of the whole shaft of the right ulna and much of the

FIG. 1
Case 1—Right elbow.

FIG. 3
Case 1—Left elbow.

FIG. 2
Case 1—Right forearm.

FIG. 4
Case 1—Left hand.

FIG. 5
Case 1—Left knee.

fifth left metacarpal (Figs. 1 to 5). Numerous large cysts were seen in those areas, and the affected bones showed well marked thinning of the cortex by absorption from the inner side. The medullary pattern was replaced in some parts by a homogeneous ground-glass appearance and in others by circular areas devoid of any bony structure or opacity. In some places large trabeculae of compact bone traversed the medullary cavity.

The changes were most marked in the right ulna (Figs. 1 and 2), the whole of which was affected. In the upper part of the shaft a number of trabeculae partly divided the cavity into separate compartments. The compact bone of the cortex was eroded irregularly. In the lower half of the shaft the cortex was almost unrecognisable in places, and everywhere very thin. The trabeculae were less well developed. Several small defects were seen in the cortex. Here and there along the shafts there was deposition of periosteal bone in small amount. The right radius showed a single large cavity just proximal to the wrist joint (Fig. 2). The left ulna showed similar changes to the right but only at its proximal end. The left fifth metacarpal showed the same changes in its distal half (Fig. 4). They were also seen above the lateral epicondyle of each humerus and at the lower end of the left femur. There was advanced arthritis in both knees, with disorganisation of the joint surfaces, especially on the left (Fig. 5). The skull, vertebral column and other limb bones showed no significant changes.

Clinico-pathological data—The results of biochemical and clinical pathological investigations are shown in Table I.

TABLE I

CLINICO-PATHOLOGICAL DATA IN CASE 1

Investigation	Date and result								
	17.2.49	23.2.49	16.3.49	9.4.49	6.5.49	1.2.50	21.4.51	17.5.51	26.5.51
Red blood corpuscles (millions per c.mm.)	5·01		4·79	4·21					
Haemoglobin (per cent)	88		80	72			87		
Leucocytes (per c.mm.)	5300		4200	4700			3600	3400	
Blood sedimentation rate (mm. hour Wintrobe)	30		25	35	20		31		
Serum inorganic phosphate (mgm. %)		4·65			4·75		3·67		
Serum calcium (mgm. %)		11·2			9·4	10·1	9·1		
Acid serum phosphatase (K.A. units %)		1·77					1·56		
Alkaline serum phosphatase (K.A. units %)					15·4	16·6	18·2		
Serum cholesterol (mgm. %)						176		173	156
Serum potassium (mgm. %)								16·9	
Serum sodium (mgm. %)								309	
Total serum protein (gm. %)								6·75	
Serum albumen (gm. %)								3·40	
Serum globulin (gm. %)								3·35	
Albumen-globulin ratio								1·02 : 1	
Thymol turbidity units									7·0
Thymol flocculation									+ + +
Sternal puncture							Normal		

Morbid anatomy and histology. *Biopsy fragments from cystic mass of right forearm and from ulna*—The wall of the cyst was a poorly vascular xanthogranulomatous connective tissue (Fig. 6), abundant in deeply eosinophilic collagen. Three special features were of interest. 1) Focal necrosis had occurred within the wall, and the inner (cyst lining) layer generally had become necrotic, melting away to form the mass of amorphous, greasy fluid noted within the cyst at operation. These areas of focal necrosis in places had a vaguely "palisade" arrangement of surrounding

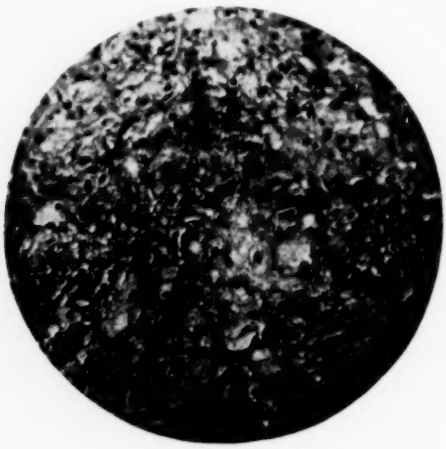

FIG. 6

Case 1.—Xanthogranulomatous tissue from wall of cyst overlying right ulna.

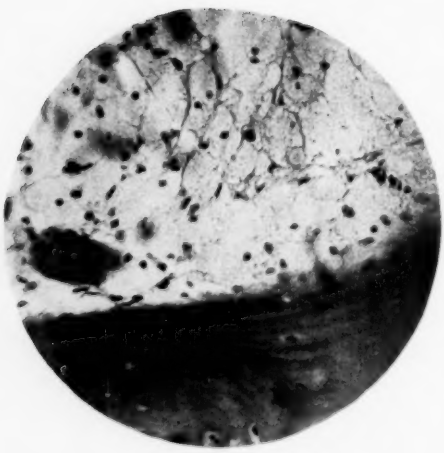

FIG. 7

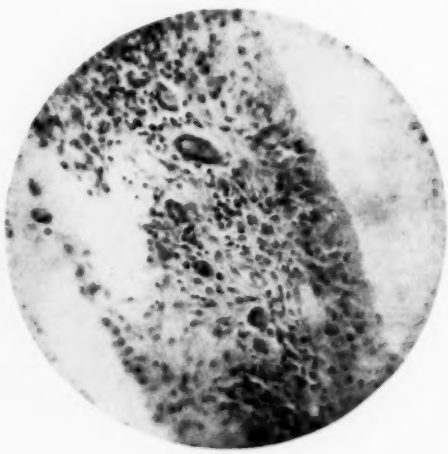

FIG. 8

Case 1. Figure 7—Foam cells in medullary cavity of right ulna. Figure 8—Chronic inflammatory reaction, with some giant cells, in synovial membrane of the left knee.

endothelial cells reminiscent of (though not so definite as) those in "rheumatic" nodules; sections suitably stained did not show acid-fast bacilli. 2) Multinucleated giant cells were present here and there. 3) Sheets of polygonal "foamy" or "xanthoma" cells, about three or four times the size of a large lymphocyte, were observed; their nuclei were central, of medium size, and dark staining; their cytoplasm was foamy and occasionally contained fine golden pigment (Fig. 7). They occurred as part of the cyst lining, and deep within the cyst wall. The outer layer of the

cyst encroached indefinitely upon surrounding skeletal muscle, the fibres of which appeared hyaline in places; arterioles, which were scanty, showed thickening of their walls.

Special stains showed the following features: mucin and glycogen were absent from all cells, but a paraffin block section stained by Sudan Black revealed many fine droplets in the cytoplasm of the xanthoma cells and abundant coarse droplets packed tightly in the giant cells. Parts of the amorphous material lying within the cyst cavity likewise took up the Sudan Black.

A section taken from within the medullary cavity of the ulna showed trabecular bone fragments in the interstices of which sheets of large foamy cells occurred in some parts, while granulomatous inflammatory tissue was evident in others (Fig. 7).

Semimembranosus bursa—Macroscopically, the specimen consisted of a large sac which, when emptied and flattened, measured 21 centimetres in length. Externally it was smooth. On opening the specimen it was seen to be thin-walled and, though it was multilocular, the greater part consisted of one large sac with a finely granular lining. The sac contained abundant yellow, greasy, pus-like fluid; several fragments of polypoidal synovial membrane were also removed from the knee joint.

Histologically, the wall of the bursa was composed of tissue showing a more chronic state of the inflammatory reaction seen in the cystic tumour from the right forearm. Where it was thin the picture was that of hyaline eosinophilic dense connective tissue with secondary invasion by giant and mobile cells. Where it was thick the inner layer (lining the sac) showed a more active inflammatory reaction which included small groups of xanthoma cells and large macrophages. Sections stained by Sudan 3 showed abundant lipoid deposits in xanthoma cells and large macrophages. The polypoidal fragments of synovium from the right knee joint showed intense infiltration by round cells of the plasma variety. The tissue was highly vascular; lining cells were swollen, as were the fibroblasts of the deeper tissue; in some places collections of xanthoma cells and, in others, small groups of giant cells were observed (Fig. 8). In places the tissue elements showed nuclear pyknosis and general staining as if in the early stage of necrosis.

Comment—There were three unusual features in this case: 1) The extensive changes in several of the bones, particularly the right ulna. In the affected bones there was destruction of the normal architecture of the bone which was so severe as to be reminiscent in places of a giant-celled tumour. 2) The two large cysts, both connected with joints affected by chronic arthritis. These cysts might be regarded as of similar nature to the Baker's cyst. But the two cysts described were much larger than the usual type of Baker's cyst, which is associated with osteoarthritis rather than with rheumatoid arthritis. Moreover the semi-necrotic lining and the contents of the cysts were unlike those of a Baker's cyst. 3) The presence of xanthoma cells in all the lesions.

Differential diagnosis—The radiographic appearances are similar to those seen in hyperparathyroidism, but the blood picture is entirely different, and the morbid histology is not that of osteitis fibrosa. In place of the developing fibrous tissue of osteitis fibrosa are found sheets of large foamy cells here and there among the granulomatous inflammatory tissue. The case cannot be fitted into any of the types of lipoidosis so far described. The absence of any affection of the bones of the skull and of other viscera are important points of distinction, as also are the associated polyarthritis and cyst formation. Although the radiographic changes in some of the bones were suggestive of giant-celled tumour, the case is distinct both clinically and pathologically. Another rare condition with a similar radiographic picture is hydatid disease of bone. But the contents of the cysts showed no evidence of hydatids, and Casoni's test was negative.

Case 2—Man aged thirty-five years. Painter. Complained of polyarticular rheumatism of seven years' duration. Both hands, the right elbow, both knees and both ankles were affected. There was a history of pleural effusion before the onset of the arthritis and examination showed diminished air entry at the base of the right lung. The right epitrochlear lymph node was enlarged, but no other abnormal features were noted on clinical examination.

Radiographic examination—The most striking changes were seen in the right elbow and the upper and lower ends of the right ulna (Figs. 9 and 10). At each end of the right ulna there was a large decalcified area suggestive of multiple cysts. The margins of the decalcified area were clear cut and the adjacent bone appeared normal. The right elbow, and the left wrist and carpal joints,

showed evidence of arthritis. In the feet, there were marked arthritic changes in the metatarso-phalangeal joints and cystic changes in the adjacent metatarsal heads.

Clinico-pathological data—The results of biochemical and clinical pathological investigations are shown in Table II. Bacteriological examination of material from a cavity in the lower end of the left radius revealed no bacterial infection. Fibrinous material removed from the right wrist joint did not yield evidence of tuberculous infection either on culture or by guinea-pig inoculation.

Morbid anatomy and histology—Biopsy specimens were taken from the lower end of the left radius, from the right epitrochlear lymph node, and from the right inferior radio-ulnar joint. *The lower end of the left radius yielded* two white irregular fibro-fatty fragments, measuring 1·5 centimetres and 1·3 centimetres in greatest diameter respectively, the smaller of which contained a piece of bone. Histologically, one of the fragments was composed of fibro-cellular tissue with villous protrusions covered by flattened "endothelium" and was heavily infiltrated by round cells (mainly plasma cells); the tissue was very vascular and the appearance suggested that this was a fragment of synovium showing marked active chronic inflammation. The second fragment consisted of bony trabeculae in the interstices of which adipose marrow was apparent in places, but for the most part it had been replaced by a loose fibrous tissue showing scattered round-cell

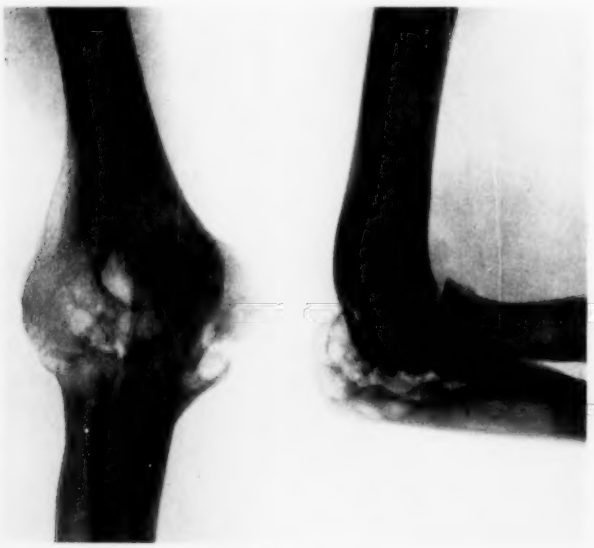

FIG. 9
Case 2—Right elbow.

FIG. 10
Case 2—Right wrist.

accumulations, mainly around the vessels. The findings suggested active chronic arthritis with myelofibrosis in adjacent bone. *The lymph node from the right elbow* showed a chronic non-specific inflammation with a mild degree of fibrosis and intraphagocytic golden pigment suggesting drainage from an area which had been the site of haemorrhage. *The specimen from the right inferior radio-ulnar joint* consisted of fibrous capsule and fragments of fibrocartilage in which there was an intense granulomatous inflammation with focal necrosis and collections of large lipoid phagocytes. The synovial lining showed intense infiltration by round cells, and tended to be buried in the inflammatory process involving the capsule. *The lower end of the ulna* was honeycombed and eroded on its articular surface. The medullary cavity contained a firm greyish-white material. Histologically, the bone was eroded by a xanthogranulomatous inflammation in connective tissue (Fig. 11); this process extended upwards from the articular surface into the interstices of the spongy bone and its marrow cavity. The xanthogranulomatous tissue varied from place to place. In some areas it contained a fairly dense background of fibrocytes and mature collagen with mobile round cells and granulocytes interspersed between the fibres, but predominantly it consisted of sheets of cells, of foam-cell type in places (Fig. 12), elsewhere having the cell outline and compact central nucleus of foam cells but with very little fine granularity of the cytoplasm. They resembled, in fact, lymphocytes in clear spaces bounded by cell membranes.

Ill defined foci of necrosis, variable in size, were frequent in this xanthogranulomatous tissue; in some of these foci polymorphonuclear cells were abundant, in others they were entirely amorphous. One focus of necrosis had become completely walled off by a fibrous capsule and formed a small cyst (Fig. 13). Occasional giant cells surrounded cholesterol clefts. Here and there dense round-cell foci (mainly plasma cells) were present. The inflammatory reaction was demarcated abruptly where the shaft proper commenced. The lesion was markedly osteolytic.

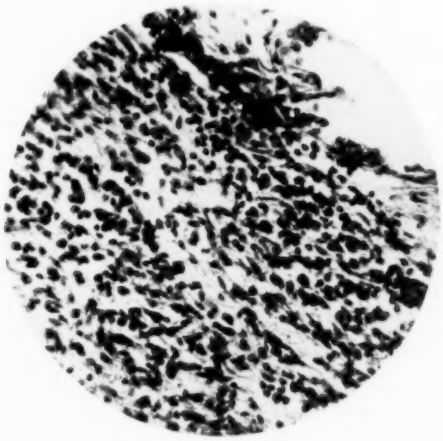

FIG. 11

Case 2.—Granulation tissue infiltrated with mobile round cells; from lower end of right ulna (×170).

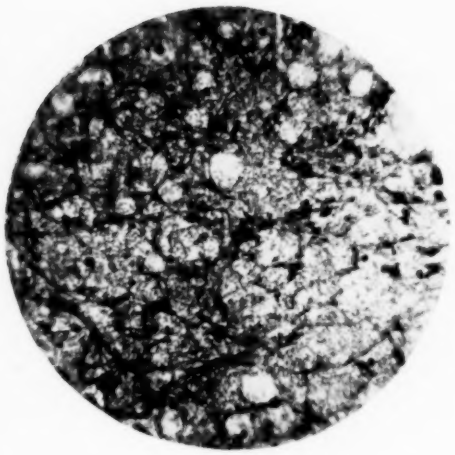

FIG. 12

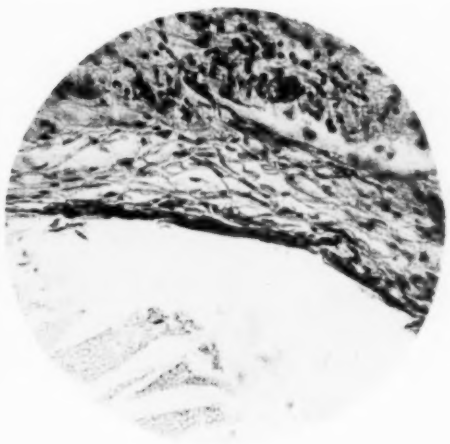

FIG. 13

Case 2.—Figure 12.—An area of foam cells from lower end of right ulna (×170). Figure 13.—Fibrous wall of microscopic cyst containing necrotic material, from lower end of right ulna.

A Sudan Black stain applied to a paraffin section showed that some of the "foam" or "xanthoma" cells contained many fine granules of a lipoid substance, but they appeared P.A.S.-negative. The lipoid staining was much less striking than it was in Case 1.

Comment.—In this case, as in Case 1, rheumatoid polyarthritis was associated with alteration of the normal architecture of bone close to an arthritic joint; and again the ulna was the

TABLE II

CLINICO-PATHOLOGICAL DATA IN CASE 2

Investigation	Date and result									
	31 1 50	7 2 50	25 3 50	6 5 50	25 5 50	19 2 51	16 4 51	30 4 51	28 5 51
Red blood corpuscles (millions per c.mm.)				4·81					4·51
Haemoglobin (per cent)	105		84	114				95	93
Leucocytes (per c.mm.)	8900		9800			8700		9700	9600
Polymorphs	59%		54%			55%		71%	56%
Lymphocytes	35%		35%			37%		21%	36%
Mononuclears	6%		6%			6%		6%	6%
Eosinophils	5%		2%			2%		2%	2%
Packed cell volume (c.c. %)	47		47	58		45		46	
Blood sedimentation rate (mm. hour Wintrobe)	24		12	20		35		31	
Blood urea (mgm. %)							29		28
Blood uric acid (mgm. %)		2·50	2·65				2·55	2·65	3·10
Blood cholesterol (mgm. %)					306	258	252		319
Serum inorganic phosphates (mgm. %)							3·81		3·20
Serum calcium (mgm. %)							9·8		10·1
Total serum proteins (gm. %)							6·50		7·25
Serum globulin (gm. %)							2·30		2·45
Serum albumen (gm. %)							4·20		4·80
Alkaline serum phosphatase (K.A. units)									9·2
Thymol turbidity units (normal = 0–4)									6·5
Thymol flocculation									

bone chiefly affected. The biochemical findings were for the most part normal, but in this case and in Case 1 the thymol turbidity and flocculation tests were abnormal, suggesting a mild degree of liver damage, and in Case 2 the serum cholesterol rose to a high normal value. Histologically the material removed from the ulna showed a xanthogranulomatous inflammation probably in an earlier phase than that in Case 1, but essentially similar to it.

DISCUSSION

These are two unusual cases of polyarthritis complicated by a xanthogranulomatous process affecting juxta-articular tissues. Examination of the literature has revealed four cases bearing at least a passing resemblance to our own, although none is precisely similar. They may be summarised thus: 1) Graham and Stansfeld (1946): A man of twenty years developed polyarthritis (simulating rheumatoid arthritis) with multiple cutaneous, subcutaneous and muscular nodules of xanthogranulomatous tissue showing what was believed to be a certain amount of neutral fat or lipoid. There was also patchy radiological bone destruction and gelatinous degeneration of marrow. The blood chemistry was normal and necropsy showed only minor changes in the viscera; death was due to progressive emaciation,

empyema, and the development of sarcoma in one of the nodules. The bony changes in this case were not the striking cystic lesions seen in ours, and the xanthogranulomatous element was in the form of nodules rather than cystic bursal swellings. 2) Layani (1939) (quoted by Graham and Stansfeld): A woman of forty-six whose illness terminated fatally after seventeen years. For the first fifteen years it was characterised by arthritis, at first monoarticular and later polyarticular; then there was a period of two or three years when progressive bone destruction was produced by xanthomatous tissue, chiefly in juxta-articular situations. Finally, she developed hypercholesterolaemia up to 1,344 milligrams per cent. The xanthogranulomatous lesions were not bursal (as in our case) and the blood cholesterol was raised. 3) Weber and Freudenthal (1933–1943): A man of thirty-five who developed pain and stiffness of various joints with temporary swelling; later, mobile cutaneous nodules up to the size of a cherry occurred over the backs of fingers, thumbs, elbows, about the face, head and buttocks, and over the greater trochanters. Histologically these nodules were masses of xanthoma cells scattered between collagen bundles. Slight hypercholesterolaemia (350 milligrams per cent) was the only important biochemical abnormality in the blood. This again was a hypercholesterolaemic disease with nodular (not bursal) xanthogranulomata, and without cystic disease of bones. 4) Fletcher (1946) recorded the case of a man aged forty-two who suffered a progressive polyarthritis simulating rheumatoid arthritis for about four years. Both olecranon bursae then enlarged and histologically were chronically inflamed, with numerous leucocytes and histiocytes; the bursal cavities contained organising fibrin. A few months later nodules attached to bony structures deep to the skin appeared over the head, scapular region, a humeral condyle, both greater trochanters, and over the lower end of each radius and ulna. They also occurred adjacent to the small joints of the feet. Most were about a quarter of an inch in diameter. The lymph nodes of both inguinal groups were enlarged. This case resembles ours only in the relationship of bursitis with polyarthritis; the nodules were histologically of "necrobiotic" type as distinct from the xanothgranulomatous inflammation we have described.

Graham and Stansfeld (1946) and Layani (1939) considered that their respective cases belonged to the "lipoidoses," and were therefore disorders of the reticulo-endothelial system. Weber (1944), however, discussing the syndrome of rheumatoid arthritis combined with multiple xanthomatous connective tissue infiltrations, suggested that the relationship of the xanthomatous deposits to the arthritis is analagous to that of gouty tophaceous deposits sometimes apparent in osteoarthritis with exaggerated Heberden's nodes. As far as our two cases are concerned we remain in doubt whether they represent extensions of the joint lesions into juxta-articular tissues, or whether they are examples of rheumatoid polyarthritis combined with a type of "lipoid reticulosis." Our present lack of knowledge makes the debate somewhat fruitless; for on the one hand we are still ignorant of the precise cause of the rheumatoid process, and on the other we are equally ignorant of the fundamental nature of the lipoidoses.

Nevertheless, certain observations may be made from the study of our cases: 1) Some of the xanthogranulomatous lesions in Case 1 showed zones of necrosis bearing at least a passing resemblance to that in the better known necrobiotic subcutaneous nodules now well recognised in certain cases of rheumatoid arthritis. In the latter, however, necrotic foci are surrounded by a definite and characteristic palisade of radially arranged fibroblasts not seen so convincingly in our case. The necrotic areas in Case 2, though just as striking, resembled pyogenic lesions that had become walled off. 2) Degenerative features in the form of eosinophilic hyaline change in collagen, together with vascular changes in the bursal lesion in Case 1, were noteworthy; they again remind one of the "rheumatic" and "para-rheumatic" diseases. 3) The more cellular regions in both cases, basically granulomatous, and containing fat-laden cells (varying from medium sized histiocytes up to large "foam cells"), nevertheless bear strong resemblance to the lesions described in the third or xanthomatous phase of Hands-

Schuller-Christian disease. In short, practically all the histological features we have described in the bones and bursae can be found in the normocholesterolaemic group of lipoidoses now considered different stages of the same disorders—namely Letterer-Siewe disease, eosinophilic granuloma, and Hands-Schuller-Christian disease. 4) It must, of course, be remembered that the so-called "xanthoma" or "foam" cells are by no means pathognomonic of the lipoid reticuloses, and similar structures are often observed in traumatic fat necroses of the breast (or other adipose regions), in the vicinity of old ovarian haemorrhages, in hydrosalpinx, and in degnerating colloid adenomas of the thyroid where haemorrhage has occurred. In short, they may appear when there is damage to lipoid-laden tissue, or when lipoid is liberated from the red cells of an old haemorrhage. 5) The abnormal thymol tests (suggesting parenchymatous damage in the liver) and the rising blood cholesterol (suggesting a disturbance of cholesterol metabolism) in the second case are probably significant, but their correct interpretation is as yet uncertain. They at least suggest that the disease process is not confined to the joints and juxta-articular tissues alone.

It is our belief that the phenomena exemplified by the above two cases—polyarthritis accompanied by xanthogranulomatous lesions in adjacent bones and soft tissue—are not as rare as they seem. Many cystic lesions of bone are noted radiographically which never come to detailed histological examination, and the problem certainly merits further investigation.

Our thanks are due to Dr H. B. Morgan, of the Manor House Hospital, for early details of Case 1. We wish to thank Dr J. Dawson for the radiological material and for his helpful advice, and Mr H. H. Langston who has allowed us to report Case 2. We are most grateful to Dr D. H. Collins of Leeds for advice and encouragement on the histological aspect of these cases.

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MULTIPLE CYSTIC TUBERCULOSIS OF BONE (JÜNGLING'S DISEASE)

Report of a Case

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In 1920 Jüngling reported nine cases of "osteitis tuberculosa multiplex cystoides," and observed that it occurred in adults, that it was practically confined to lesions of the hands and feet, and that there were no sequestra or sinuses. He considered that the cases were tuberculoid in origin and were caused by an avirulent tubercle bacillus. In some respects

FIG. 1
The right forefoot.

FIG. 2
The left hand.

they showed features closely related to Boeck's sarcoidosis. Other reports in the literature have appeared under the titles multiple cystic tuberculosis of bone (Thornton 1938), Besnier-Boeck-Schaumann disease and Perthes-Jüngling disease. Birdsong and L'Engle (1948) found reports of only fourteen cases in the literature. Since that date, several further cases have been described by Frost (1942), Fox (1944), Jacobsen (1936), Kreidberg and Downing (1948) and Law (1939). In some cases children have been affected. Miliary lesions affecting the flat bones have been reported by Meng and Wu (1942) and Kienböck (1931) has described multiple cystic tuberculosis affecting only the long bones. Turkish *et al.* (1949) pointed out that Jüngling, reporting this disease in 1920 and 1928, noted the following characteristics: 1) Gradual onset during puberty or thereafter. 2) Pain occurred early and was not severe. 3) The small bones of the hands and feet were affected. 4) Cystic degeneration was seen on radiographic examination. 5) No involvement of periosteum or joints was present. 6) Often there was involvement of skin in the affected area (sarcoid). 7) No tubercle bacilli were

discoverable. 8) Tuberculous skin tests were usually negative. 9) Histology showed epithelial and lymphocytic cells and occasional giant cells, but no caseation or tuberculous bacilli. 10) The disease took a slow course, tending to spontaneous improvement and even recovery. The reported cases of the disease in children had differed in that tuberculin skin tests were usually positive, guinea-pig inoculations or cultures were not infrequently positive, caseation was occasionally noted, associated skin lesions were only rarely seen, the long hollow bones were sometimes involved, and, although local lesions had a tendency to heal, the patient frequently died of generalised tuberculosis.

CASE REPORT

An adult Bantu patient complained of a swelling of the right metatarso-phalangeal joint of three months' duration. There was only slight pain. On examination the swelling of the foot was bony-hard. There was no attachment to skin and no tenderness, scars, sinuses or local heat. In the left hand, in the region of the first metacarpal bone, there was a diffuse swelling without joint involvement. This was also bony-hard, not tender or hot, and without evidence of sinuses. In the neck there were multiple small shotty glands in the posterior triangle, with larger glands in the left submental and right submandibular region. There was a broad scar in the upper part of the left side of the neck, extending over the parotid region; the patient stated that this had discharged spontaneously in childhood.

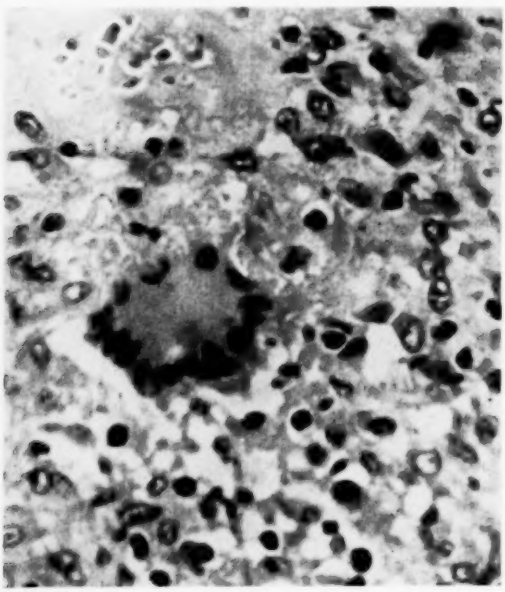

FIG. 3

Section from metatarsal lesion showing tuberculous granulation tissue with giant cell.

Radiographs of the left forefoot (Fig. 1) showed destruction of the metatarso-phalangeal joint by a cystic trabeculated lesion. There was expansion of the bone and good definition of the cystic spaces. Erosion with bursting of the shell of the cortex was possibly present only in one area. The lesion was diffuse, extending through the whole of the proximal phalanx and proximally to the middle of the metatarsal. Radiographs of the left hand showed similar but less extensive cystic changes in the first metacarpal (Fig. 2).

Differential diagnosis—Radiographically the lesion did not suggest a tumour. Syphilis, common in the Bantu, was unlikely, as sclerosis of an irregular nature with gross periosteal new bone is the usual feature. Pyogenic osteitis required consideration, but the trabeculated cystic appearance without gross sclerosis or bone abscesses was against this. Gout was considered, but there was no evidence of chalky calcified areas, and the clinical lesion was painless and did not resemble gout. The numerous cystic areas favoured a diagnosis such as medura-mycosis, but this was excluded by the absence of sinuses and induration. The bones were too well calcified for osteitis fibrosa cystica.

The remaining possibilities were tuberculous dactylitis and Boeck's sarcoidosis. Brailsford (1944) described a trabeculated cystic form of tuberculous dactylitis. The metacarpal lesion,

with changes confined to the bone without involvement of the joints, together with the shotty glands in the neck and an old neck scar over the left parotid, and an increased sedimentation rate, supported a tuberculous origin. With regard to Boeck's sarcoidosis, the lungs were perfectly normal, there were no skin nodules and no evidence of uveoparotitis; but the serum proteins showed a total of 8·4 grammes per cent (albumen 4, globulin 4·4). This state of the proteins is a common finding among Bantu population and cannot be regarded amongst them as specific for sarcoidosis.

Treatment—The lesion of the foot was excised completely and a bone graft from the right ilium was inserted. Fixation was obtained by the use of a probe extending from the tip of the right first toe through the distal phalanx and the graft into the small remaining part of the first metatarsal, supplemented by a plaster splint. After three months the probe and the plaster were removed, and the patient was encouraged to walk.

Description of specimen—The cut surface of the specimen had a light brownish fleshy appearance and contained numerous bony spicules and fibrous bands running through its substance. *Microscopically*, sections showed the specimen to consist, for the most part, of tuberculous granulation tissue, in which there were numerous giant cells of the Langhans type, with well marked follicle formation (Fig. 3). Foci of caseation, scattered irregularly throughout the granuloma, could also be seen. In addition, a few bony trabeculae and fibrous connective tissue were present. Very scanty acid- and alcohol-fast bacilli were observed. The histological features were those of a tuberculous dactylitis.

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A NEW PATTERN OF BONE-HOLDING FORCEPS

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Existing patterns of bone-holding forceps for plating or grafting fractures of the long bones seem to have been designed with the object of holding together three objects simultaneously—namely, the two ends of the fracture and the plate or bone graft that is to be screwed to them. In that technique the bone-holding forceps are used in pairs; one forceps holds one of the bone fragments and one end of the graft or plate, and the opposite end of the plate or bone graft is held to the corresponding bone fragment with the other forceps. To get the fracture reduced and clamped to the graft or plate often requires considerable juggling, and maintenance of the reduction is impeded by the fact that the graft or plate obscures inspection of the fracture line. The blades of the forceps have to be comparatively narrow so that they do not cover more of the surface of the graft or bone plate than is available between two screw holes, and narrow blades reduce the rigidity of the clamping action. The Lowman clamp has the additional disadvantage that it must be passed underneath the fragments, and thus complete stripping of the bone ends is necessary on the deep surface.

The clamp described here (Fig. 1) holds in rigid alignment the two fragments of the fracture alone and then the graft or plate can be screwed to the exposed surface without any need for the graft or plate to be held by the clamp. The essential feature is the design of the detachable jaws, which are provided in three sizes. For the plating or grafting of long bones the jaws carry a single longitudinal gutter on the surfaces which are opposed to each other. The fractured long bone is gripped in these jaws, and the parallel gutters then automatically coax the fragments into alignment as the curved surfaces of the fragments settle into the grooves under the pressure of the clamp (Fig. 2). The jaws are pivoted at their point of attachment to the forceps so that the pressure of the forceps is distributed equally to both fragments, and this pivoting action enables the fragments to be held even if they are of different diameters or if the bone tapers at the site of fracture. The forceps can be applied without stripping the deep surface of the fracture. The fragments can be adjusted to obtain a " hairline " fit with the fracture line fully exposed and with the certain knowledge that this reduction will be maintained when the fracture line is obscured from vision by the application of the plate or graft.

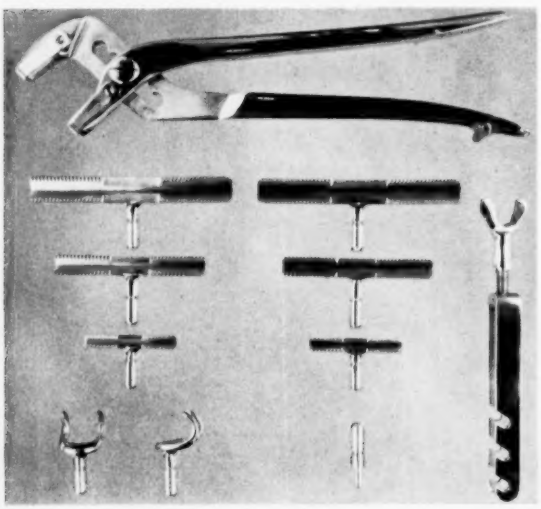

FIG. 1

The forceps with range of detachable jaws.

In bone grafting with this clamp the exposed surface of the bone lying in the grip of

the clamp can be " planed " down with a chisel to give a flat surface extending accurately from one fragment to the other, so that the graft can be securely bedded against the fracture.

The smallest pair of parallel jaws are used for the radius and ulna while the other two sizes are available for large bones; it is, however, often surprising how the small pair of jaws can be used for even large bones.

To complete the range of usefulness of the instrument special jaws are provided for holding fractures of the patella, olecranon and medial malleolus. For the patella, two hooked

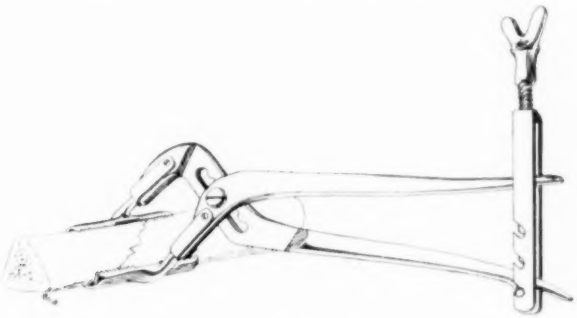

Fig. 2

Grooved jaws, pivoted at their attachment, used for gripping long bones in bone grafting or plating.

Fig. 3

Fig. 4

Figure 3—Hooked jaws used to grip a fractured patella. Figure 4—Hooked jaw and peg used to grip fractured olecranon.

jaws are used in the manner shown in Figure 3, which is self-explanatory. For the olecranon and medial malleolus one of the hooked jaws acts against a " peg-shaped " attachment in the opposite jaw of the clamp. For this a one-eighth inch drill-hole is made in the shaft of the ulna or tibia to receive the peg in the manner illustrated (Fig. 4).

This instrument has been on trial for over two years and is regarded as an important addition to the fracture surgeon's armamentarium. It is manufactured by Chas. F. Thackray Ltd., Park Street, Leeds 1.

THE MOVEMENTS OF BONES AND JOINTS

5. The Significance of Shape

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There are no flat articulating surfaces. This is a fact of anatomy, but it was to have been expected upon the basis of the *Law of Incongruence* put forward by Walmsley (1928) in this Journal. Walmsley did not use the expression italicised above; he stated his law in the form of two independent theorems: 1) that no articular surface is a surface of revolution; and 2) that no one of a pair of articulating surfaces is congruent with its fellow except in one position, which is characteristic for each joint. We have called this position the synarthrodial or close-packed position, and have demonstrated that the incongruence found in all other positions is an aid to the efficient lubrication of the joint. Flat surfaces would be congruent in every position.

Further, the articulating surfaces are not even ruled surfaces—that is, no line drawn upon them can be straight. This fact determines the kinematics and the kinetics of the synovial joints, for it determines the geometry of the movements carried out by one surface upon another. It is true that some surfaces are so lightly curved that, loosely, we may call them "flat"; but careful examination will show that even these are curved in the sense implied throughout this paper. We may call this "anatomical curvature"—the mathematician calls it the second, or Gaussian, curvature of the surface, after the celebrated Gauss, who wrote so much upon this topic. There are two kinds of anatomical curvature. One has been called elsewhere the *ovoid* type, the other has been called the *sellar* type (MacConaill 1946). The sellar type is that of which the saddle-surface is a special case; it is a surface which is convex in one direction but concave in another. The ovoid type is one of which both the humeral head and the glenoid cavity are special cases; it is either convex in all directions or concave in all directions. The term "ovoid" directs attention to the fact that such a surface is more like a piece of egg-shell than (say) a sphere, in that its curvature varies continuously from point to point, the same being true of sellar curvatures as well.

Since the curvature of an articular surface varies from point to point, so that no two points have the same curvature, and since the curvature at corresponding points differs from man to man, one has to consider the dynamics of the synovial joints in terms of a highly generalised geometry. This geometry can give us results which reach no more exact quantitative expression than the terms "equal to," "greater than" and "less than." These, however, are sufficient for us to establish a comparative dynamics of ovoid and sellar joints, which can be verified by observations upon both normal and abnormal joints. It is this comparative dynamics that gives significance to shape, and that will be dealt with in this paper. The dynamics of joints in which one bone articulates by means of two distinct surfaces—the condylar joints—will be the subject of a later paper.

The geometrical basis of articular dynamics has been discussed elsewhere (MacConaill 1946). The conclusions reached will be stated and used here as the need arises. The essence of the affair is that articular dynamics are referred to the joint surfaces themselves, not to external co-ordinates as has been the custom hitherto, with the notable exception of Goodsir (1868). Goodsir's approach, however, involved many unnecessary assumptions, and he lived before the intrinsic geometry of curved surfaces was as fully developed as it is now. Rudolph Fick (1910), on the other hand, deliberately brought the ovoid and sellar types of surface

into a single dynamical scheme, upon the assumptions that the joint surfaces were in contact during movement as when at rest, and that the deformability of articular cartilage could, therefore, be invoked to offset differences in form between the two types of surface. His primary assumption, that the surfaces remain in contact when in motion, is disproved by the demonstration that they are in fact separated by films of synovial fluid. Hence there is a clear need for a dynamics that takes account of the anatomical differences between the two types of joints; the questions posed by structure are never meaningless.

Definitions—In all that follows terms such as "point," "line," "path" and "area" refer to points, lines, paths and areas *lying wholly on the surface*. We assume, however, that these can be viewed by an observer situated outside any such surface; this "physical assumption" enables us to circumvent certain difficulties that would be impassable to the pure mathematician.

The shortest distance between two given points will be called a *chord*. The word "rotation" will be used in its medical sense: that is, a rotation about an axis perpendicular ("normal") to the surface. A simple translation ("slide") along a chord produces no rotation of the translated body; this can be proved rigorously. Such a movement produces what we have earlier called a swing (MacConaill 1948). Any line between two points, everywhere concave towards the chord between them, will be called an arc: this definition accords with that in ordinary (plane) geometry. There will be two angles between any arc and its chord, one at the origin and one at the termination of the arc. These are the angles subtended by the arc.

A uniform translation—or slide—along a linear path is a movement during which a given line in the moving body always makes a constant angle with the path. This has elsewhere been called a "self-parallel" displacement. When the path is an arc, the moving body undergoes a *conjunct rotation*, the magnitude of which is equal to the sum of the angles subtended by the arc: just as it would be in similar circumstances upon a flat surface. The *curvature* of an arc is defined as the conjunct rotation per unit length of arc, as in plane geometry. This is, indeed, the only definition of curvature that is applicable to arcs on all kinds of surfaces. A conjunct rotation achieved by means of a slide along an arc will be called a *monodal* conjunct rotation (Gr., mono-hodos = single-path). This is to distinguish it from a conjunct rotation consequent upon a slide along two successive paths—a diadochal path. The comparative dynamics of ovoid and sellar joints is mainly an affair of monodal conjunct rotations, as will now be seen.

THE COMPARATIVE DYNAMICS OF OVOID AND SELLAR SURFACES

By the angular sum of a three-sided figure we mean the sum of its three internal angles. This is two right angles when the figure is bounded by straight lines. It is not two right angles (in general) when the figure is bounded by curved lines. A triangle bounded by chords is the equivalent on a curved surface of one bounded by straight lines on a flat surface. Such a "chordal triangle" has an angular sum that differs from two right angles. It is less than two right angles on a sellar surface, and greater than two right angles on an ovoid surface (Figs. 1 to 3). The comparative dynamics of joints depends upon this *law of triangles*. The reader is now referred to Figures 4 and 5. Let QRS be an arc of a circle having its centre at P, so that PQ and QS are radii. It is not presumed that these radii are equal, but they do cut the circumference at right angles; this is all we need to know. Let QS be the chord proper to the arc QRS. Then a body sliding from Q to S along the arc will suffer a conjunct rotation equal to the sum of the angles RQS and RSQ. We wish to compare the conjunct rotation so brought about upon a sellar surface with that upon an ovoid surface. The arcs must be comparable. They are comparable if they are both concave towards the apical angles QPS, if these apical angles are equal, and if the lengths of the arcs are also equal. The last of these three conditions is not strictly necessary, but arcs of equal length have to be considered at

a later stage in any case. By a simple application of the law of triangles it can be shown that the sum of the angles subtended between the chord QS and the arc QRS is less than the apical angles on an ovoid surface, but greater than it on a sellar surface. Hence the curvature of comparable arcs is greater on a sellar surface than on an ovoid surface (arcs of equal length). Therefore, *the same monodal conjunct rotation will be achieved by means of a smaller expenditure of energy upon a sellar surface than upon an ovoid surface*, other things being equal; for the

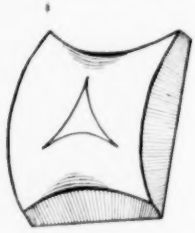

FIG. 1

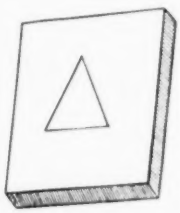

FIG. 2

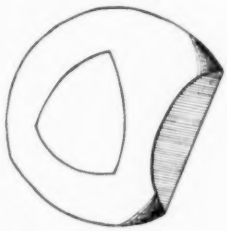

FIG. 3

Triangles formed by chords upon a sellar surface (Fig. 1), by straight lines upon a flat surface (Fig. 2), and by chords upon an ovoid surface (Fig. 3). See text.

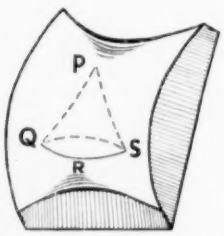

FIG. 4

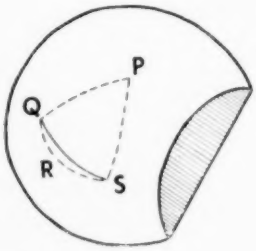

FIG. 5

Comparable arcs upon a sellar surface (Fig. 4) and an ovoid surface (Fig. 5). QRS—arcs; QS—chords to the arcs. The angles QPS are equal, as also are the arcs.

work to be done (energy expended) will depend wholly upon the length of the path, as we know from general mechanics. Conversely, the same expenditure of energy—or length of path—will produce a greater conjunct rotation upon a sellar surface than upon an ovoid. From the standpoint of monodal conjunct rotation, the sellar surface is kinematically and kinetically superior to the ovoid. The reverse is true of the conjunct rotation caused by sliding along the second "leg" of a diadochal path; but this effect is most noticeable in large joints.

EXAMPLES FROM NORMAL ANATOMY

It is, then, not surprising that a sellar surface is found to be characteristic of joints at which we have "opposition" as a habitual movement—as, for example, at the carpo-metacarpal joints of the thumb and little finger. Again, this type of joint surface is found in the synovial joints between the lumbar vertebrae, at which the so-called "lateral flexion" is really a rotation, as this term has been defined above; the amount of this rotation between any two lumbar vertebrae is surprisingly great in view of the normal close interlocking of the articular surfaces involved. The sellar nature of these surfaces is, of course, best appreciated upon fresh, cartilage-covered specimens.

Most sesamoid bones appear to have the sellar type of articular surface. The pisiform bone, for example, has to pull its tendon (piso-carpal ligaments) in a curved path during the movement that is compounded of flexion and adduction of the wrist. That is to say, it must execute a conjunct rotation over a monodal path. The pisi-triquetral joint is,

accordingly, of the sellar type. By way of contrast, we may cite the metacarpo-phalangeal joints. Here conjunct rotation (not to be confused with "circumduction") is very small, and the surfaces are ovoid, not sellar. In this connection it may be recalled that conjunct—as distinct from simple, or adjunct—rotation is relatively less at the shoulder and hip than at the saddle-joint of the thumb, for example. The absolute amount may be more, but the length of the path traversed by the moving part is greater in monodal motion.

We may take an example of particular interest from the lateral side of the foot. Here we have a chain of bones, the metatarso-cubo-calcanear chain. It has been shown that this chain undergoes a torsion, or twisting, when the feet are moved from being beside each other to being far apart (MacConaill 1945). The movement is barely perceptible at the metatarso-phalangeal joint; it is appreciable at the cubo-metacarpal joint; and it is of considerable magnitude at the calcaneo-cuboid joint. This last joint also shows an abduction (laterally) of the heel-bone; so the movement is clearly one of conjunct rotation. This joint is also the only one of the three to conform to the sellar type.

FIG. 6

FIG. 7

A labid thumb shown in extension (Fig. 6), and in flexion (Fig. 7) of the interphalangeal joints. The radial element has a sellar interphalangeal joint, and has rotated (pronated) markedly in flexion.

EXAMPLES FROM ABNORMAL ANATOMY

At some stage in scientific investigation we must generalise, but generalisation should not be more sweeping than the facts appear to indicate. In the present case the generalisation takes this form: Sellar surfaces imply monodal conjunct rotation. The alternative form of this rule is: The absence of monodal conjunct rotation implies the absence of a sellar surface. A law of this kind is called an implicative law. It is to be distinguished from a correlative law. The "correlative" form of our generalisation would involve the statement: The absence of a sellar surface implies the absence of monodal conjunct rotation, a statement that is clearly false. Many scientific laws are of the implicative type, and there are probably more of this type than of the correlative type in biology.

In 1946 the writer made the following statement, when discussing the dynamics of intra-articular displacements: "The more efficient saddle surface is employed in forming that joint at which conjunct (as distinct from independent) rotation is a chief aim." Within the

last year two cases of bifid thumb have come under the author's observation. They were both in living men, and have supplied what appears to be confirmatory evidence—found after, and not before, the assertion of the general law given above. In the first case (Figs. 6 and 7), the terminal segment alone was bifid; the condition was confined to the right side. Both terminal elements flexed and extended together, but the radial element rotated—in the sense of a pronation—during flexion, while the ulnar element did not do so sensibly. Radiography showed that the proximal segment was also divided internally, there being two phalanges articulating with one and the same first metacarpal bone. The ulnar joint was of the ovoid type characteristic of the normal metacarpo-phalangeal joint, but the radial joint was of a well-marked sellar type. In the second case (Figs. 8 and 9) both segments were bifid; this case was also right-sided. The patient could not flex or extend the pair of bifid elements, but he could carry out opposition of the double thumb. When he did so it was observed that the rotation of the ulnar element was greater than that of the radial: the first was more "pronated" than the second. Radiography showed that the radial element was

FIG. 8

FIG. 9

Another bifid thumb shown in reposition (Fig. 8), and in opposition (Fig. 9). The ulnar element articulates with the metacarpal by means of a sellar joint, and has rotated more than the thumb as a whole during the movement of opposition.

fixed seemingly immovably to the metacarpal bone; the ulnar element, on the other hand, articulated with the same bone by a well defined saddle joint. In this case, conjunct rotation of the ulnar element was apparently superimposed upon the conjunct rotation of both elements at the carpo-metacarpal joint, so that the ulnar element rotated more than the radial.

MOVEMENTS AT THE INTERPHALANGEAL JOINTS

The movements of the interphalangeal joints of the fingers have a special interest, in that they have led to the discovery of a law hitherto unsuspected. These joints are hinge-joints; but flexion and extension at them is always accompanied by some rotation; this rotation is specially easy to observe in the index and little fingers. During flexion the terminal phalanx of index rotates so that its palmar surface turns towards the corresponding surface of the thumb. The middle phalanx undergoes a similar but lesser conjunct rotation. These movements are best seen by bringing the finger into radial deviation while in full

extension, and keeping it so while flexion is carried out. Similar movements are carried out at the interphalangeal joints of the other fingers; they are best observed by laying the more proximal phalanx of the finger of one hand alongside the corresponding phalanx of the other hand. For example, one would lay the middle phalanx of the right little finger against the middle phalanx of the left. The rotation of the basal phalanx upon the metacarpal head is insensible, or rather, nearly so. This " bimanual comparison " is essential for a clear perception of the rotatory movements.

The reader will now understand why the movement at an interphalangeal joint should be more evident than that at a metacarpo-phalangeal, for the first is of the sellar kind while the second is ovoid. But why should a hinge-joint show rotation at all? Why should we not have a pure swing? The answer is, that this conjunct rotation, apart from any other possible function it may serve, assists in safeguarding the articular cartilage. This will now be demonstrated.

ISOCURS, GRADIENT LINES AND PATHS OF MINIMAL SHEAR

Isocurs—The anatomical curvature of an articular surface varies from point to point, generally speaking; but we can find an infinite number of lines upon the surface along each of which

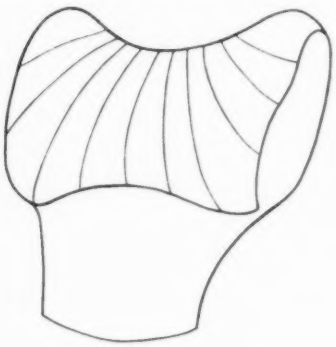

FIG. 10

FIG. 11

Scheme of a phalangeal head showing, in Figure 10, some lines of equal anatomical curvature (isocurs) and, in Figure 11, some gradient lines to the same isocurs.

the curvature is constant. These " contours " of curvature cannot cross one another, just as contours of height upon a map cannot cross one another. They will not be, in general, chords upon the articular surface (Figs. 10 and 11). We may call them *isocurs*, this word is short for " isocurtal lines " (Gr., *isocurtos* = equally curved).

Gradient lines—Let there be a set of lines, each line crossing all the isocurs on a surface at right angles. Every such line is called a *gradient line*, for it corresponds to the line of steepest ascent (or descent) traced across the contour lines of a map. The gradient lines and isocurs of a surface (Fig. 12) form a set of natural co-ordinates upon the surface, because certain important physical properties of the surface can be simply expressed in terms of them.

Paths of minimal shear—The magnitude of the area of a triangle upon a curved surface is given by the equation $A = T/K$, where A is the area, T is the difference between the angular sum of the triangle and two right angles, and K is the average curvature of the area enclosed by the bounding chords of the triangle. It follows that $T = AK$. Consider now a thin triangle made of some flexible and stretchable substance, so that it can move about upon the surface and keep in contact with it at every point, while its area remains constant—say, A square units. Hence as K changes so will T, and the change will be strictly proportional. It is clear that as A moves along some gradient line (Fig. 11) K will change; but if A moves along some

isocur, K will not change. By the definition of a gradient line, the rate of change of K will be greatest (per unit of distance) if it move along the gradient line; less—but yet more than zero—if it move along some line which makes less than a right angle with the isocurs; and zero if it move along an isocur. We know that T changes proportionately and directly with K; hence what has been said about K applies, *mutatis mutandis*, to T. That is, a movement along an isocur is a motion that leaves T unchanged, but a movement along a gradient line is one of maximal change of T.

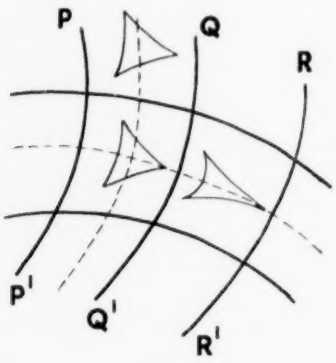

FIG. 12

A deformable triangle moving along an isocur (direction P^1Q^1—PQ), and along a gradient line (direction PP^1—RR^1). It is most deformed (strained) in the latter case. See text. PP^1, QQ^1, RR^1—isocurs.

Movement of a triangle upon a flat surface—one of zero curvature—leaves the angular sum of the triangle unchanged: this was the implicit assumption that dominated Euclid's geometry and the mechanics based upon it. The reader will understand, then, that if our triangle moves from a region of lesser to one of greater curvature, its angular sum will come to differ more than before from two right angles, and it will undergo a marked deformation in shape (Fig. 12). On the other hand, should it move along an isocur it will undergo (at most) such an alteration in shape as would leave its angular sum unaltered. This latter deformation will be the least possible, and will be—like the former—a strain due to a shearing stress: hence, we may conclude that *isocurs are paths of minimal shear stress.*

ARTICULAR PATHS OF MINIMAL WORK

It is the functional essence of a synovial joint that the fixed and the moving surfaces are separated by a film of synovial fluid while movement is in progress. The synovial fluid is viscous, so that one layer of the fluid moves over another while movement continues. The fluid layer immediately adjacent to the fixed surface is adherent to it and practically of the same shape. The next layer moves on this fixed layer, and is subject to shear forces imposed upon it by the movement of the lamina nearer to the moving surface; and so on until we arrive at the fluid layer adherent to the moving surface. Work must be done by the muscles controlling the moving surface to overcome the viscous resistance to shear offered by the laminae of synovial fluid. We have seen that the shear will be of least amount when it occurs along an isocur. Hence, isocurs are paths of minimal work done to secure efficient lubrication by viscous film lubrication.

We may, then, expect that isocurs, or paths approximating to them, will be the paths traversed in the habitual—or characteristic—" effort-movements " of the joint. There will only be one such movement in a hinge-joint, or indeed, at any one joint; for example, the habitual effort-movement of the carpo-metacarpal joint of the thumb is opposition. We may call paths of habitual effort-movement *ergodes* (Gr., " work-paths "), and say that ergodes are paths of minimal friction; for the shear stresses that are set up by movement are a form of frictional resistance to motion, and such stresses are a waste of energy except in so far as they set up the counter-pressure necessary for efficient lubrication, as has been demonstrated in an earlier paper.

INTERPHALANGEAL ERGODES

The details of the articular surface of the head of a phalanx are important evidence in favour of the motions set out above. The bulk of the surface is of the sellar type—of negative anatomical curvature, to use the mathematical description. But the ulnar and radial margins are of the ovoid type—they are of positive anatomical curvature. It is clear that one and the same isocur cannot run from the radial to the ulnar margin of an interphalangeal articular

surface. They must, therefore, run from the dorsal to the palmar margin. Such lines, as has been mentioned, will be arcs, not chords. Hence a phalanx following such a path will suffer a conjunct rotation. We have seen that an arc on a sellar surface is more curved than a comparable arc on an ovoid surface; hence the conjunct rotation observable over a small length on a sellar surface will be more than the conjunct rotation observable on an ovoid surface. This is the probable explanation of the marked supinatory rotation of the terminal phalanges of the fingers during flexion. It is a movement that brings the terminal part of the index (for example) into opposition with the adducted thumb, a fact made use of by those who thread needles to sew.

Space does not allow of an extensive description of joint surfaces considered in the light of the principle of ergodes. One other example must suffice—the humero-ulnar joint. The surfaces here are sellar surfaces, and their margins, like those of the phalangeal heads, are ovoid. We can place the trace of the ergode with some assurance as dorso-ventral. The rotation of the ulna during cubital flexion and extension is small but sensible, and the anconeus muscle is well placed to assist that rotation in the phase of extension. It may be remarked, finally, that further consideration of the conjunct rotation of hinge-joints must be deferred until we come to consider the close-packed position. In joints provided with intra-articular cartilages the conjunct rotation assists in bringing about that helical deformation which must take place for their most efficient working (Boswall 1928).

If there be any substance in the account of the intrinsic dynamics of the synovial joints put forward above, one clinical application seems to follow. Whatever be the end intended by the arrangement of articular ligaments, that arrangement must allow the conjunct rotation imposed upon the moving part by the shape of the fixed surface. Any disorder of the ligaments preventing that rotation, and (as the writer believes) forcing too " direct " a path upon the moving bone, will lead to increased friction and to increased wear. The detail of surgical repair takes significance from shape.

SUMMARY

1. The dynamics of synovial joints depends upon the geometry of the articular surfaces, which are always curved.

2. There are two types of articular curvature: ovoid (synclastic) and sellar (anticlastic).

3. The sellar type is mechanically more suited to movements in which sliding is combined with medial or lateral rotation (monodal conjunct rotation).

4. The movement of any hinge-joint is accompanied by a monodal conjunct rotation. This carries the moving part along a path that approximates (at least) to a path of minimal wear. The same is true of the paths of habitual effort-movement (ergodes) of other kinds of joint.

5. Evidence for the foregoing statements is drawn from both normal and abnormal joints, and a clinical application is suggested.

I wish to thank Dr W. F. M. Fitzgerald, of this department, for the line drawings; and Captain J. Mahn, D.M.R.E., of the Irish Army Medical Corps, and Dr T. R. O'Keefe, D.M.R.E., of Cork South Infirmary, for the radiographs shown in Figures 6 and 7 and 8 and 9 respectively.

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HISTORICAL SURGICAL INSTRUMENTS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND

A first selection of Instruments and Apparatus on view during the Orthopaedic Congress of the English-speaking World, July 1 to 3, 1952

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Clerk of the Museum, Royal College of Surgeons of England

Although the Instrument Collection in the Museum of the Royal College of Surgeons of England suffered considerable loss through enemy action in May 1941, it still contains many interesting and historical specimens. Owing to the present limited museum accommodation, the collection must remain in store until it may be possible to place it on view in the building now in process of erection.

At the request of the president of the combined meeting of the Orthopaedic Associations of the English-speaking World, held in London during the first week in July 1952, a selection

Fig. 1

Left—Liston's " setting instrument " with wooden sheath. Top centre—Syme's ankle knife. Below is shown a plaster cast of the hand of James Syme holding his ankle knife. Right—Two saws designed by William Adams.

of instruments and apparatus was taken out of store and placed on exhibition in the museum for the benefit of overseas visitors and others attending the College for meetings and for the Robert Jones and Moynihan Memorial Lectures. In this article reference is made to some of

the more interesting of these exhibits, and it is proposed to include in future issues further selections of instruments which have historical associations or an interesting story. This will enable readers of the *Journal of Bone and Joint Surgery* to get some idea of what was to be seen during the congress in the display of old surgical instruments and apparatus, and to learn of other specimens in the College Museum Collection.

A " setting instrument which belonged to, and was originally carried by, Mr Liston " consists of a polished steel rod, a quarter of an inch in diameter, mounted in a wooden case (Fig. 1). The wooden sheath when removed exposes the whole length of the rod, five and a half inches; it is also made to unscrew near its middle so that a length of only two and one-eighth inches is bare. Surgeons down to Liston's day kept steels of this kind in constant use to sharpen the edge of the knife. At the beginning of the nineteenth century some were made with ivory handles and kept in morocco-covered cardboard cases.

A knife which deserves particular mention is the ankle knife used by Syme in all his classical amputations of the foot performed in the old Edinburgh Infirmary (Fig. 1). Syme gave it to Edward Lawrie in 1869, who passed it on to the late Sir Lenthal Cheatle in 1906; he in turn presented it to the museum in 1931. Edward Lawrie, who qualified in 1867, published a communication " Upon the results of the Hyderabad Chloroform Commission " (1894) and was the author of " Chloroform: a Manual for Students and Practitioners " (1901). A plaster cast of the hand of James Syme holding his ankle-knife, recently presented to replace the original model lost when the museum was bombed in 1941, was also on view (Fig. 1).

There were two examples of the saw designed by William Adams (1810–1900), one being the original pattern used in the first operation for division of the neck of the femur, and the other with the improved " pistol-shaped " handle (Fig. 1). William Adams gives a full account of the operation which he devised at the Great Northern (now the Royal Northern) Hospital in " A new operation for bony anchylosis of the Hip-Joint with Mal-position of the Limb by Subcutaneous Division of the Neck of the Thigh-bone " (1871), where this identical saw was employed on November 26, 1869. The second example shows the improved handle " which was first made by Mr Blaise for Mr Jowers of Brighton, who found a stronger purchase in the handle than that which I (Adams) had previously used, was desirable."

FIG. 2

R. W. Tamplin's combined sharp- and blunt-ended tenotomy knife

A beautifully made instrument was that of R. W. Tamplin, F.R.C.S. (1814–1874). On a single handle of ebony are mounted combined sharp- and blunt-ended tenotomy knives. The instrument consists of two knives lying side by side, one with a sharp-pointed and the other with a blunt-ended blade (Fig. 2). The sharp point being exposed, the tissues are punctured and the blade inserted as far as necessary. When the tendon or muscle to be divided is reached, the blunt-ended blade is pushed forwards by means of a thumb-catch working in a slot in the handle to guard the parts from the sharp point; thus the two blades become one cutting edge with a blunt end. Tamplin in 1842 was the first to divide the posterior tibial tendon in infants for talipes varus. He was one of the original 300 Fellows of the Royal College of Surgeons of England. Five other tenotomy knives, preserved in a case, were employed, and presented, by William Adams who worked with Tamplin at the Royal Orthopaedic Hospital.

Of the cases of instruments three are deserving of mention. The first is a British Army surgeon's case of instruments, most of which were made by Stodart about 1800 (Fig 3). It was presented in 1932 and belonged to the great-grandfather of the donor, who probably used it at the Battle of Waterloo. It contains, among other instruments, five amputation knives—three with curved backs and two (large and small) with double-edged straight blades—finger saw, trephines, bullet forceps, dental key and tourniquets. The second is a brass-bound mahogany case of Army Regulation pattern made by Weiss about 1830 (Fig. 4). Of the four amputation knives two are of the Liston pattern for the flap operation, a third

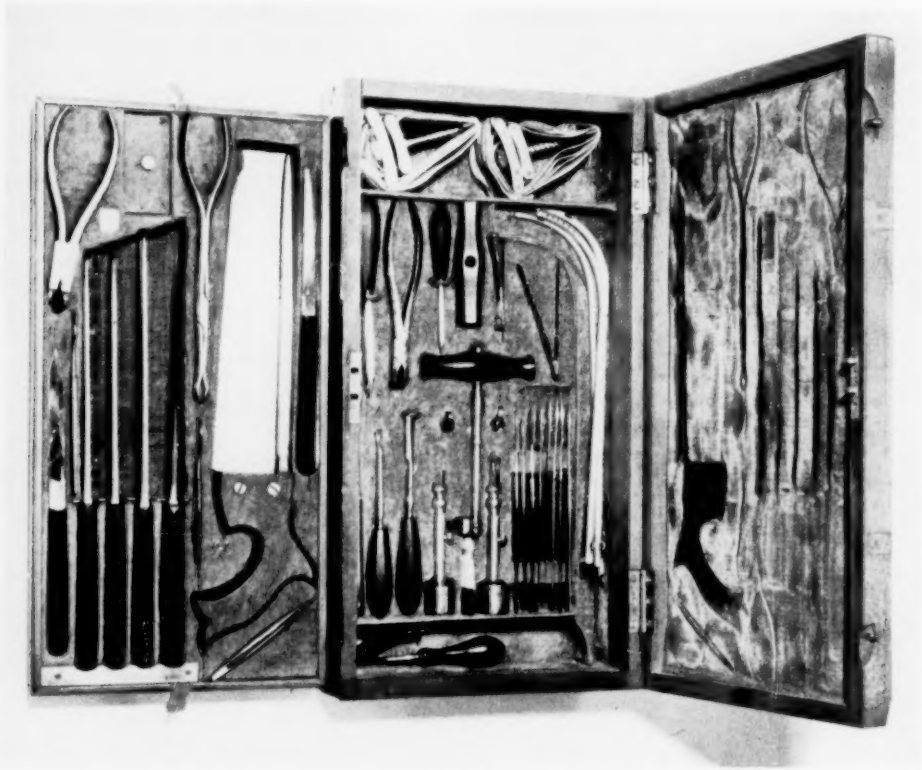

FIG. 3

British Army surgeon's case of instruments made by Stodart about 1800.

for the circular operation, and the fourth and smallest a catlin or interosseous knife. There are two saws. An amputation saw contains Weiss's improvement, which consisted of a series of "slots" at half-inch intervals throughout the cutting edge, or, as the maker's catalogue of 1863 states: "the slots in the blade have the effect of clearing the teeth of the saw during the operation." The other saw is a finger saw. There are also two Hey's saws, trephines, trocars, tourniquets, coin-catcher, etc. All the instruments are in a good state of preservation and show the beautiful workmanship that went into their manufacture. On the lid of this case there is a brass plate inscribed "D. S. E. Bain, Staff Surgeon." David Stuart Erskine Bain (1823–1888) qualified in 1843 and became a F.R.C.S. (Ed.) in 1859. He was appointed Assistant Surgeon to the 80th Foot and retired with the honorary rank of Deputy Inspector General in 1871. The third case of instruments was made by J. Gray and Co. of Sheffield

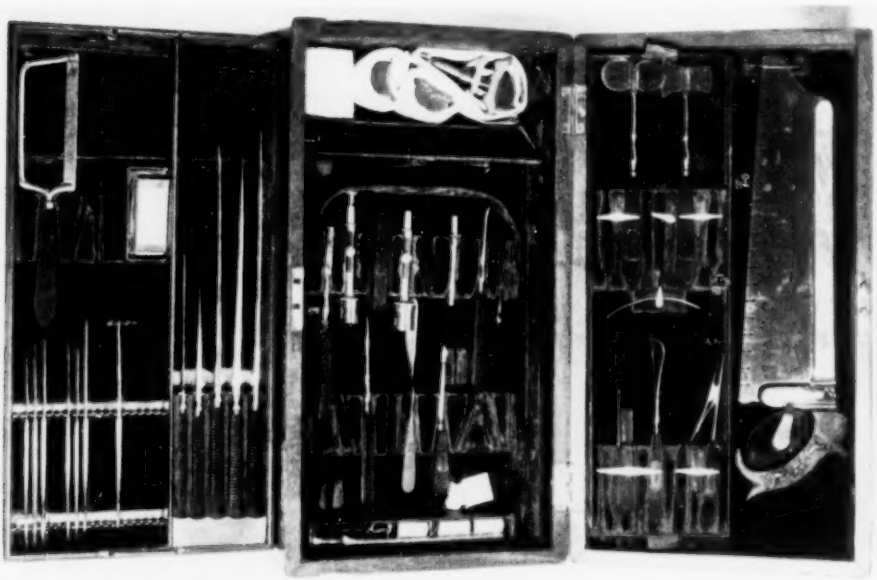

FIG. 4
Case of instruments by Weiss, made about 1830.

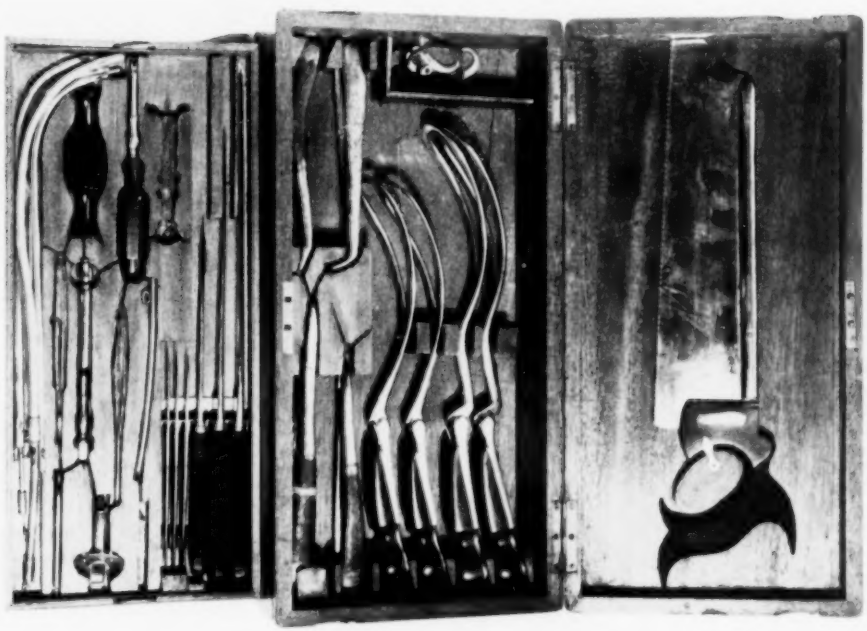

FIG. 5
Case of instruments made about the middle of the nineteenth century by J. Gray and Co. of Sheffield. Formerly the property of Captain Watson, ship's master.

probably about the middle of last century (Fig. 5). It includes three Liston's amputation knives of different sizes, tracheotomy tube, dental key, dental forceps and elevator and two

FIG. 6

Above is shown a case of trephining instruments dating from the middle of the eighteenth century. On the left is a drill stock of Petit's pattern and on the right is a similar instrument of eighteenth century design. Below, centre, are a trephining saw with levers for removal of bone disc made by Boog and Co., and a forceps for removing the circular piece of bone cut out by the trephine.

pairs of midwifery forceps (Denman's and Blundell's). This case formerly belonged to Captain James Watson, ship's master, and was carried by him when in sail sometime after 1862. Captain Watson was born in 1833 at Aberdeen and obtained his master's certificate in

January 1862 in that city. He was master of the Colonial-Aberdeen tea and wool clippers *Granite City* and *Ocean Mail*, each carrying 300 to 400 passengers to Australia. About 1880 he transferred to the old Monarch Line, London, and was master of the *Egyptian Monarch*, troopship to Port Sudan and Suakkim for General Gordon and Sir Garnet Wolseley. Next he transferred to the London-New York Service, and took " Jumbo " to New York in the *Assyrian Monarch* in 1887 for which he received the thanks of the Royal Geographical Society. In 1896 he returned to the sea in charge of *Hesperides* for two voyages and made a record passage. He died in 1928.

Trephining instruments were represented by two cases dating from about the middle of the eighteenth century. One case contains a manuscript note: " This case of trephining

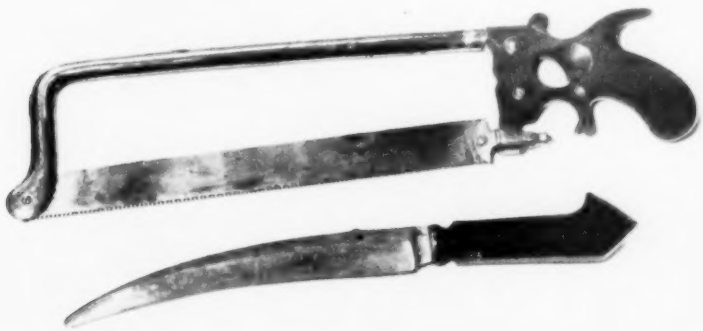

FIG. 7

Above is a large amputation saw. Below it is a curved amputation knife with lignum vitae handle. Both date from the middle of the eighteenth century.

instruments belonged to the late Mr Winterbottom, Member of the Corporation of Surgeons of London and was presented to the Royal College of Surgeons of England, to be deposited in the Instrument Museum, by Thomas Radford, M.D., F.R.C.S.Edin., F.R.C.S.Eng., September, 1874 " (Fig. 6). Most of the instruments in this case are illustrated in Samuel Sharp's treatise on the operations of surgery (1739), Plates 8 and 9. The other case contained instruments of similar design and date of manufacture. Of the two drill stocks, one was a Petit's with artistically fashioned stock and highly ornamented ball-grip and thumb spring-catch for releasing the shaft of the saw from the stock, stamped " Paris " surmounted by a trefoil (Fig. 6), an excellent illustration of which is figured in Scerig's *Armamentarium* (1838), Plate 74. The other (Fig. 6) resembles somewhat the drill stock figured in Brambilla's *Instrumentarium* (1782), Plate 9. An elaborate trephining saw made by Boog and Co., a firm which became extinct about 1870, bears on each side a spring lever controlling parts of the saw containing three teeth (Fig. 6). By this mechanism the disc of bone can be raised after it has been cut by the saw. The last trephining instrument to be mentioned is a pair of forceps for removing the circular piece of bone cut out by the trephine (Fig. 6). This was illustrated and described by Samuel Sharp in Plate 9 of his treatise. " Upon one of the handles is added a little Elevator to lift up any small Splinter of Bone, but it is not of much use." It was presented to the Museum in 1805 by a Mr Grice, who founded a firm later known as Krohne and Sesemann.

Two instruments made about the middle or towards the end of the eighteenth century were a bow saw for amputations (Fig. 7) (figured in Sharp's treatise of 1737) and an early

example of a curved amputation knife (Fig. 7) with lignum vitae handle turned upwards at its free end to prevent the hand slipping, and bearing what is presumed to be a finger-rest on the back of the blade near the handle. The handle of the saw is shaped for the fingers and thumb, and has a hole, round on one side and oval on the other, for the forefinger (this hole is not shown in Sharp's illustration). The frame is engraved with a design on each side

FIG. 8

The formidable instrument above is a circular saw for cutting bone. It was driven by a coiled spring. Presented in 1871. Below it is Machell's saw with forceps to grip the bone.

of its free end. The cutting blade is attached to the frame by two screws, and can be tightened from the handle end by a nut. The knife is called " Perret's " in Seerig's *Armamentarium* (1838), Plate 131, but in J. J. Perret's *L'Art du Coutelier* (1772) the two illustrations of amputation knives on Plate 124 are quite different in design, having a more distinct curve with sharp-pointed blades. Sharp, in Plate 14A of his treatise of 1739, illustrates a knife of similar design to the example shown and states that it should be about thirteen inches in length; the specimen exhibited measures thirteen and a half inches. Both of these instruments

bear a similar cutler's mark, a star surmounted by a crown. Maker's names did not appear on instruments until the latter part of the eighteenth century.

A formidable instrument was a circular saw for bone (Fig. 8). The saw is nine inches in diameter, has very large teeth, and works with geared cogs on a coiled spring. It is mounted on a wooden handle bearing a steel finger-guard, and weighs 2 pounds 14 ounces. It has no maker's name or trade mark, and has not been identified in any publication. It was presented to the museum by W. H. B. Winchester in 1871.

A sample of Machell's saw with forceps to hold the bone (Fig. 8) is evidently a modification of that surgeon's original pattern. An article entitled "Description of an Annular Saw; by Mr Machell, Surgeon of Walsingham," appeared in the *London Medical and Physical Journal*

Fig. 9.

Gooch's splints (above) compared with cane splints made by the Kenyah tribe in Sarawak. At right and left are Gordon's splints for treatment of Colles fracture.

(1815) and was republished with additions and a plate in the *Edinburgh Medical and Surgical Journal* (1815), where the author wrote: "I am induced to give the following description of my annular saw from the very flattering reception it has met with from the Earl of Stanhope, by whose approval and patronage I have been honoured, and also by several surgeons of the highest professional eminence in the Kingdom, by whom my annular saw is acknowledged to supersede the use of the trephine, trepan, Hey's saw, bone-nippers, rasp, the mallet and chisel, etc., in all cases where any portion of carious bone demands the interference of our art to remove it."

Examples of splints were two pairs described and illustrated by Benjamin Gooch (Fig. 9) in "Cases and Practical Remarks: with Sketches of Machines of Simple Construction, Easy Application and Approved Use" (1758). "It is made of deal one-eighth of an inch thick, with leather glued to it, and cut through to the leather to the distance of one-sixth of an inch . . ." By the side of Gooch's splints for comparison were two cane splints of the kettle-

holder type (Fig. 9), made and used by members of the Kengah tribe, Barham District, Sarawak. They consisted of thin flat pieces of cane, lying parallel and held together with fibrous cords near each end and in the middle. The right and left Gordon's splints (Fig. 9) for treatment of Colles fractures of the radius are described and figured in "A Treatise on the fractures of the lower end of the radius, etc.," published in 1875 by Alexander Gordon, M.D., Professor of Surgery, Queen's College, Belfast. W. H. B. Winchester's cradle for fracture of the tibia and fibula (Fig. 10) consists of two mahogany bars, each carrying a row of adjustable pads, seven on one and six on the other. The pads allow the surgeon to adapt the pressure to the form of the limb.

Three model beds (Fig. 11) aroused interest. The first was a fracture bed in which the mattress fixed to a brass frame can be elevated and tilted at various degrees to the right or

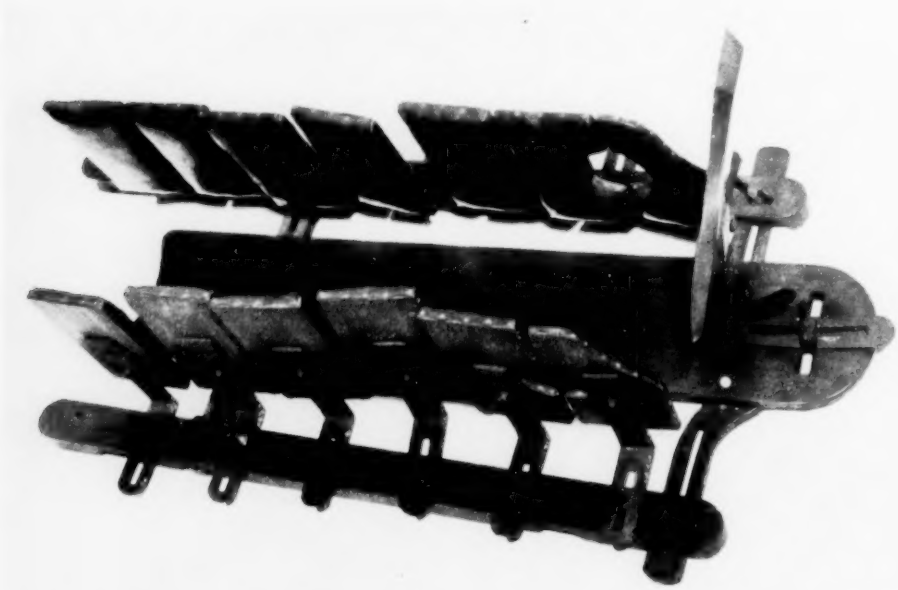

FIG. 10

Winchester's cradle for treatment of fractures of the tibia and fibula. The pads are adjustable to conform with the contour of the limb.

left; the second a bed invented by W. H. B. Winchester (Fig. 11) and exhibited in the International Exhibition of 1873, in which the bedding can be removed and changed without disturbing the patient; and the third a bed invented by James Luke (Fig. 11) for fractured thigh, etc., in which a frame fitted on pivoted rods can be elevated so that the mattress below can be removed.

W. H. B. Winchester (1816–1901), whose name has been mentioned several times in the foregoing notes, became F.R.C.S. by election in 1853; he invented a number of pieces of orthopaedic apparatus and received honourable mention at the International Exhibition of 1862 for improvements in splints for fractures.

A spinal support with stays (Fig. 12) for incipient lateral curvature consisted of a triangular steel frame engraved with a florid pattern, and made to be adjusted to the amount of deformity. It is fitted with straps so that it can be fastened securely under the axillae.

FIG. 11

Models of three early beds. On the left is a fracture bed with tilting mattress. In the middle is Winchester's bed designed to permit changing of the bedding without disturbing the patient. On the right is a fracture bed designed by James Lake; the top frame can be elevated so that the mattress below may be removed.

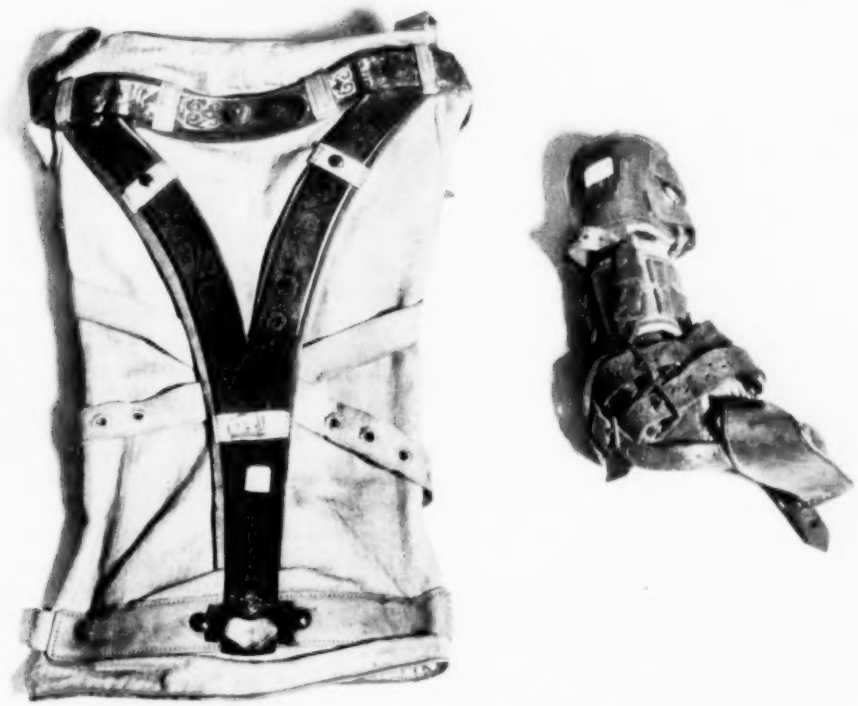

FIG. 12

Left—Spinal support with engraved steel frame. Right—Scarpa shoe for treatment of talipes equino-varus. This specimen had been worn by the donor for eighty years.

This frame is adjusted to a surgical corset, which laces in front. The specimen, which was in the museum when the first manuscript catalogue of the instrument collection was compiled in 1878, has no history or donor's name. The Scarpa shoe (Fig. 12), used in a case of talipes equino-varus, was worn by the donor for eighty years.

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THE INFLUENCE OF HUGH OWEN THOMAS ON THE EVOLUTION OF THE TREATMENT OF SKELETAL TUBERCULOSIS*

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My first duty is to thank you for the very great honour extended to me by your invitation to deliver the Hugh Owen Thomas Memorial Lecture. We do well to remind ourselves about this great man and to reflect on what he was able to achieve from general practice, without the facilities attaching to a hospital staff appointment. Much of what he taught has become fundamental in the treatment of skeletal injury and disease; he is now universally recognised as an outstanding pioneer in the early development of orthopaedic surgery.

Hugh Owen Thomas received a medical training in no way different from that of his contemporaries. He served a four years' apprenticeship at St Asaph with his maternal uncle, Dr Owen Roberts, before proceeding to Edinburgh University and University College, London. He qualified as a Member of the Royal College of Surgeons in 1857. But to this formal medical education there was added a knowledge of the treatment of skeletal disabilities which he derived from his own people. From them he learned to adopt a conservative attitude towards chronic joint disease, and in treating a fracture to aim at restoration of length and alignment, using pulleys for this purpose when necessary. It is this ancestral background that explains the uniqueness of Owen Thomas, for it instinctively led him to the study of injuries and diseases of the locomotor system. Furthermore he was able by his medical training to discriminate what was valuable in the practice of his family whilst preserving a critical attitude towards regular orthodox treatment. In the pursuit of his work he found it necessary to establish at Nelson Street an orthopaedic clinic, a small hospital, and a well equipped workshop. These three were complementary; they were essential for the care of his patients and the working out of his ideas. In this establishment one sees in embryo the pattern of the modern orthopaedic hospital—the out-patient clinic, the hospital, the instrument workshop. It was familiarity with this type of effective organisation for the study and treatment of skeletal disabilities that enabled Owen Thomas's apprentice and nephew, Sir Robert Jones, to set up a similar arrangement at Baschurch which became the model forerunner of country orthopaedic hospitals.

The study of skeletal tuberculosis was one of Owen Thomas's main interests in life and in view of the encouraging change that has taken place in the curative prospect of this crippling disease during these last few years I thought it might be appropriate to trace the evolution of its modern treatment which he did so much to initiate. In the cure of this disease Thomas had two guiding principles. The first was the inherent tendency to recovery which many patients exhibited. In this respect he closely followed John Hunter, who was deeply impressed by the natural resistance of the body to disease and by its struggle against anything impairing the function of one of its parts. The sole business of a surgeon was that of a helper, claiming no more for his operation than lending his aid in that struggle. Within our own experience some of us have met individuals with a kyphosis whose spinal radiograph revealed a healed destructive disease which could have been no other than tuberculosis and for which no treatment was received.

The second principle was rest. The idea of rest as a therapeutic agent Thomas discovered for himself but he was strongly supported in this belief by his study of the prize memoir of Jean-Pierre David "On Motion and Rest in relation to Surgery" which was published in Paris in 1778, and also John Hilton's lectures on "Rest and Pain" delivered at the Royal

* Hugh Owen Thomas Memorial Lecture delivered at the Liverpool Medical Institution on November 13, 1952.

College of Surgeons from 1860 to 1862. Rest for Thomas had a precise meaning; it could only be obtained by striving for perfect immobility.

His way of treating a tuberculous joint paid obedience to these two principles—the promoting of the natural recuperative power of the patient and the securing of complete rest for the morbid part. His procedure was first described by him in 1875 in his book entitled *Diseases of the Hip, Knee and Ankle Joints*. He had given his method an extensive trial, checking his results on more than a thousand patients before proclaiming his principles of treatment. This publication at once revealed Thomas as an original thinker in surgery.

In the case of the hip joint the two signs that roused his suspicion of disease were pain and limping, but the sign that he regarded as almost diagnostic was shortening or contracture of the adductors and particularly if accompanied by gradually increasing flexion of the limb. The constancy of this last sign induced him to devise a simple means of both detecting and estimating the degree of flexion, a procedure that has become classical as Thomas's flexion test for hip disease. The patient lies on his back on a plane surface whilst the sound thigh is flexed by the surgeon until the knee touches the chest, thus ensuring a straight spine. The presence and extent of flexion of the diseased hip is thereby revealed in spite of any voluntary attempt at extending the limb.

In the early stage of the disease Thomas kept his patients in bed, and encouraged good feeding and nursing in fresh air. Even in dwellings of the very poor he insisted on nursing crippled children out of doors on beds improvised for the purpose. He was fully alive to the value of rest, fresh air and sunshine in the cure of joint tuberculosis and was probably about the earliest surgeon to adopt, as common practice, this threefold therapeutic aid in the treatment of the malady. By his general care of his patient he undoubtedly helped to reduce the toxaemia that is present in a varying degree in the active stage of tuberculosis whatever the local manifestation may be. And in the protection of the diseased joint he was uncompromising, for nothing less sufficed than "enforced uninterrupted and prolonged rest"—to quote his oft repeated formula—procured by mechanical fixation with splints devised specially for the purpose. The most striking feature of his splints was their simplicity of design; they were so simple that any village smith and saddler could make them. They had reached their final form after much trial and error during which Thomas forged the iron with his own hands. The hip splint had several characteristics of its own; unlike other appliances it relied on posterior fixation and by extending from just below the level of the axilla to the calf it was more certain of securing joint immobility, and by preventing deformity it thereby placed the limb in a favourable functional position in the event of ankylosis. When greater control of joint or patient was desirable, as in the very young, a double splint was used during recumbency.

The double hip splint was also valuable in the correction of flexion deformity by slow stages; a procedure founded on Thomas's doctrine of "unsoundness." An unsound part was one in which inflammatory processes were occurring as the result of disease or injury; a joint or fracture in such a state was plastic and therefore pliable. On this doctrine he based much of his practice in correcting deformity. He treated a flexed tuberculous hip joint by first accommodating to the deformity the corresponding part of a double hip splint (Fig. 1). In the course of a few weeks this section of the splint, with the limb bound to it, was gradually straightened until flexion was abolished, after which treatment of the joint continued. An abscess sometimes prolonged the period of recumbency; it was frequently aspirated until it disappeared.

In the treatment of the disease of the knee joint Thomas applied the same principles as in that of the hip. He produced a splint for the purpose in 1865, the most famous of all his splints (Fig. 2). By it he was enabled to exercise control of the knee joint even more effectively than by the hip splint in the case of the hip and walking was permitted earlier in knee disease (Fig. 3). The splint consisted of an ovoid ring for the groin connected by

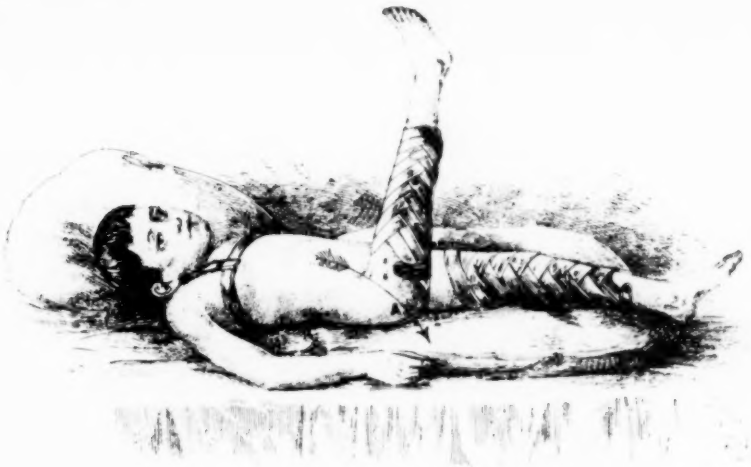

FIG. 1

A patient on a double hip splint showing Thomas's method of gradual correction of a flexed hip.

FIG. 2

Thomas's knee splint as it first appeared in a drawing in 1875.

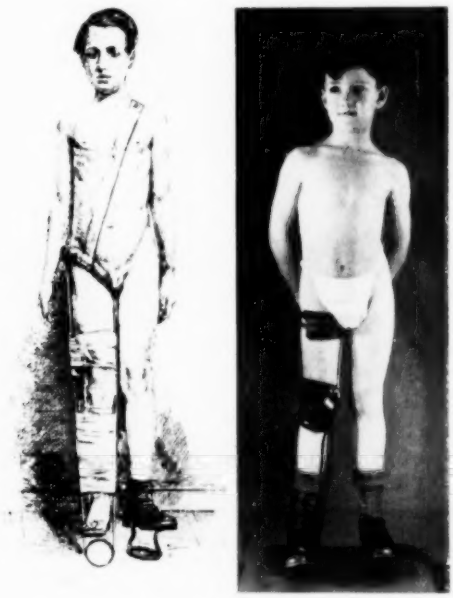

FIG. 3

1875—Thomas's ambulatory treatment of right knee disease (left). 1952—Ambulatory treatment of Perthes disease of hip (a patient of Mr K. I. Nissen) (right).

two iron rods to a smaller ring below. The inner rod was attached to the upper ring at an angle of fifty-five degrees reduced to forty-five degrees after padding, which was thicker on the inner side. The outer rod was fixed to the apex of the ovoid ring and the inner was attached at a plane in front, the ring being flatter at the groin than at the back.

Nothing is more symbolic of the genius of Owen Thomas than his knee splint; surprisingly simple in construction but peculiarly adaptable in its uses. Introduced first for tuberculosis of the knee and used subsequently for fractures of the lower limb, it began as a splint of recumbency and later was found to permit of treatment with ambulation. Its astonishing use in two world wars is well known; the number of limbs it saved and the suffering it alleviated in transport are beyond reckoning. In civilian practice it is a basic equipment wherever fractures are treated.

Thomas started a new era in the treatment of tuberculous joints. He demonstrated clearly how a cure could be obtained and function restored to a limb by relying on inherent power of recovery, resting the patient, and absolute protection of the diseased joint surfaces from friction. When he first proclaimed the gratifying effect of this conservative procedure there was no certainty amongst surgeons as to what kind of treatment should be adopted; splints were used but amputation or joint excision was a frequent occurrence! At one university centre excision of the hip had a mortality of over 30 per cent and the recovery of many of those that survived was very prolonged.

The teaching of Owen Thomas was slow in spreading but there were some surgeons who immediately grasped the significance of what he taught and adopted his splints. Among them were Rushton Parker in Liverpool, Edmund Owen and Thomas Bryant in London, Professor Thiersch in Germany and John Ridlon in America. Ultimately the hip splint began to appear in the teaching hospitals. The good effect of prolonged immobilisation was so convincing that radical operations diminished and conservative control of skeletal tuberculosis came into favour.

JOINT FUSION BY BONE GRAFTING

In the first decade of this century surgeons became increasingly aware that a joint with osseous destruction, even if cured of the disease, was often stiff, painful, insecure and liable to relighting of the malady. In order to cure the patient of these symptoms and to restore comfortable function to the limb there appeared to be no alternative but to accept the destruction of the joint as a total loss and proceed by operation to produce ankylosis. Indeed this had often been the natural process of cure of a joint which was grossly destroyed. But the experience of previous generations in their operative attack on a tuberculous joint was gloomy and forbidding. Operation was therefore revived in another form by the use of a bone graft which avoiding the infected joint yet joined its osseous elements to each other. Human bone grafting was first introduced by Sir William Macewen in 1879 when he helped in the restoration of the shaft of a humerus, destroyed by osteomyelitis, by sewing bone chips in the bed of the lost bone. His subsequent researches on bone growth led him to lay emphasis on the necessity of a good blood supply for the recipient bone and adjacent tissues.

In 1911 Russell Hibbs and Fred Albee, both of New York, independently introduced extra-articular spinal fusion for destructive disease of the spine. Albee, who was a master craftsman, made great use of a long bone graft removed from the inner surface of the tibia by electrically driven twin circular saws. The strip of bone, which extended from above to below the diseased vertebrae, was grafted into the clefts of split spinous processes which were ultimately fused into one continuous bone, thereby permanently immobilising the infected segments. The operation was performed after a period of recumbency on a Thomas or Bradford Frame, which allowed the disease to become quiescent. It had the advantage of reinforcing the weakened spine and prevented recurrence of the disease. The great virtue of Albee's operation was that it imposed as little strain as possible on a debilitated patient;

there was the least muscle stripping and a proper regard for the nutrition of the graft by its enveloping tissues. Bone grafting more often fails because of the inadequacy of the blood supply rather than from any fault of the graft.

Albee's procedure can be extended to accommodate two grafts while paying due deference to graft nutrition (Figs. 4 to 6). The muscle is stripped off the spinous process on one side only, just enough to admit a secondary graft; the face of the process is chipped to expose cancellous bone in several places. About a third of each process is next split off, bearing with it its attached muscles; into the cleft the main graft is placed and a second graft into the opposite osteo-muscular groove with their compact periosteum-bearing surfaces uppermost. The grafts should fit snugly in their new abode and require no metallic aid for their security; the suturing of muscle and aponeurosis over them helps their fixation.

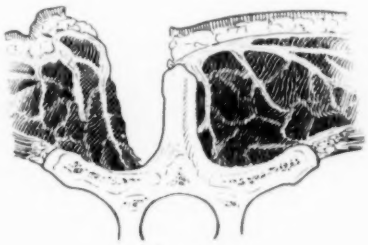

FIG. 4

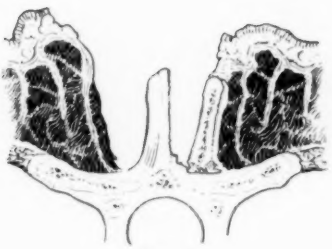

FIG. 5

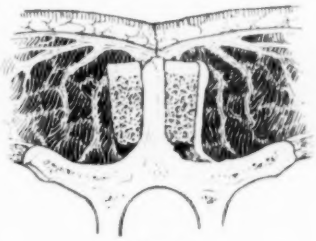

FIG. 6

Three stages of spinal bone-grafting. Figure 4—Muscle stripped off one side of spinous process just sufficient to admit a graft. Figure 5—A section of spinous process split off with its muscles intact. Figure 6—Grafts in place with muscle and aponeurosis sewn back.

A similar procedure was adopted in tuberculosis of the hip joint. Albee used an extra-articular bone graft which extended from a prepared cleft in the ilium to one in the greater trochanter. In later years fusion of the femur to the ischium has found favour because the resulting ankylosis is better adapted to take the stress of weight bearing. This method was first adopted by Trumble in 1932 and was improved upon by Brittain (1943), who guided the graft between the raw bone surfaces of a McMurray's osteotomy into a prepared cleft in the ischium.

Extra-articular fusion was a distinct landmark in the treatment of skeletal tuberculosis. In 1914 Mark Rogers of Boston, dissatisfied with the late results of many tuberculous knees treated by conservative means, revived excision; gradually this operation gained ground. When the femur or tibia is seriously eroded it is now the accepted practice, after the disease has become quiescent, to aim at fusion by a classical excision of the articular surfaces and diseased synovial membrane. A method of pressing the bone surfaces to each other and their fixation by pins transfixing the bones, introduced by Albert Key in 1932 and improved by Charnley's apparatus, is a valuable contribution in facilitating ankylosis.

SPINAL CARIES WITH PARAPLEGIA

The next considerable advance in the treatment of skeletal tuberculosis has been that of spinal caries with paraplegia, a most distressing complication. The renewed attention to this aspect of the disease was stimulated by the extensive studies of Seddon and Butler. Although the spine is the commonest site for skeletal tuberculosis the vast majority of patients with spinal disease make a good recovery with prolonged immobilisation. But the presence of paralysis adds greatly to the gravity of the malady and is always a menace to the survival of the patient. The most frequent site of spinal cord pressure is the mid-thoracic region, where normal kyphosis is greatest and where the calibre of the spinal canal is smaller than elsewhere, thus allowing little accommodation for debris or exudate. The usual cause of paraplegia is an abscess which may be fluid or semi-solid due to caseation; confined behind

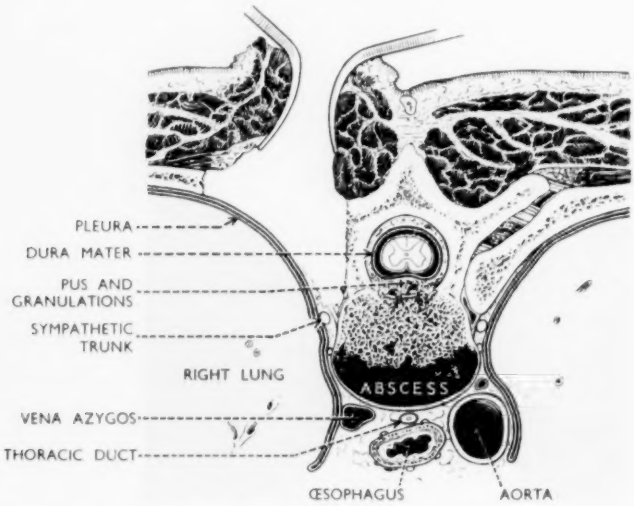

FIG. 7

Costo-transversectomy. The right rib and transverse process have been removed. The abscess is contained between the eroded body of the vertebra and the stretched anterior common ligament. The exudate filtering back, through the crumbling vertebra, into the spinal canal presses on the cord. The abscess is approached between the exposed pleura and vertebra.

the anterior common ligament, it travels through the crumbling vertebral body into the spinal canal and exerts extra-dural pressure on the cord. Much less often the obstructing object is a displaced sequestrum or degenerated disc.

There are two clinical types of paraplegia, one occurring during the early active stage of the disease and the other—paraplegia of late onset—appearing in a patient cured of the malady who has been getting about comfortably but with an obvious kyphosis; the paralysis is usually due, as Butler contends, to a relighting of the disease.

The treatment in both types is immobilisation in a plaster-of-paris bed with a turning lid. The paralysis gradually disappears in the great majority of patients treated in this way. But there is a small minority of patients who do not respond to recumbency; the paralysis even increases and they steadily degenerate. The only hope for them is by operation. The question arises how long should a surgeon wait before operating. In the past there has been a tendency to wait too long, hoping against hope that at last a spontaneous recovery would occur, while the general condition of the patient gets steadily worse. It may be accepted that if a patient with paraplegia from spinal caries, who is being skilfully nursed in a plaster-

of-paris bed, shows no sign of recovery within eight weeks then operation is clearly indicated. These patients are bad subjects for operation and further deterioration in their physical state should be avoided. There are two operations that offer a good prospect of relief—costo-transversectomy and antero-lateral decompression.

Costo-transversectomy, introduced by Menard in 1900, aims at direct evacuation of the abscess (Fig. 7). A longitudinal incision is made about one inch lateral to the spinous processes with its centre opposite the collapsed vertebra. The muscles are incised and retracted, and a selected rib and transverse process are stripped carefully. The process is disarticulated from the rib and removed; three or four inches of rib are excised, care being taken in disarticulating it from the vertebral body. The real danger is perforation of the pleura which in these patients is sometimes adherent to the rib. The finger is next cautiously

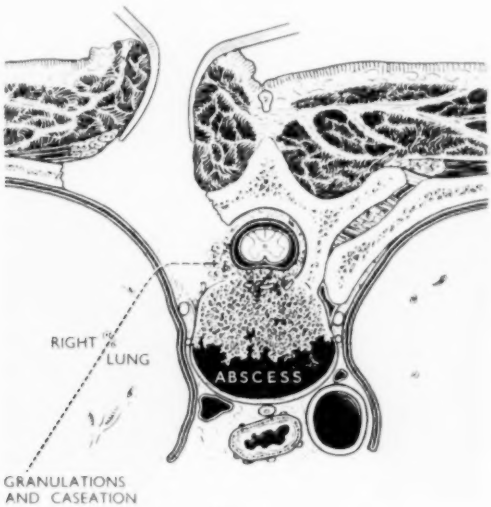

FIG. 8

Antero-lateral decompression at the level of sixth thoracic vertebra. The right rib, transverse process and pedicle have been removed exposing the spinal canal and allowing direct access to whatever is extra-durally pressing on the cord.

insinuated between the rhythmically moving pleura and the body of the vertebra until the abscess is reached whose wall usually perforates on slight pressure from the finger tip. Fluid pus is mopped up until the abscess is completely evacuated. If the contents of the cavity consist of solid caseation they can be removed by ladling them out with a large curette spoon. If there is fluid pus a drainage tube is left in for forty-eight hours, the muscles are sewn back and the skin incision closed. Healing usually occurs but occasionally complete healing is delayed by the formation of a sinus which may last for two or three weeks. It is therefore an advantage to continue nursing the patient on the back in a plaster-of-paris bed, rather than on a lid.

Antero-lateral decompression aims at relief of any pressure on the spinal cord by exploring the spinal canal (Fig. 8). It was first carried out by Capener at Exeter in 1933, and independently developed some years later by G. L. Alexander and Norman Dott at Edinburgh. The steps of the operation are the same as in costo-transversectomy but the pedicle, as well as the transverse process and rib, is excised and at least two ribs, processes and pedicles require removal. The dura mater is thereby exposed and by carefully

lifting it the cause of the spinal cord pressure is revealed. More often it is due to a mass of granulation tissue or caseation but occasionally it is due to a sequestrum, a bone spur or degenerated disc. The offending tissue or exudate is removed and any abscess is evacuated.

Antero-lateral decompression is a much more serious procedure, for the lateral supports on one side of two or more diseased vertebrae are removed and there is the added risk of perforation of the dura mater which in the presence of fluid pus may produce tuberculous meningitis. If a radiograph reveals a well defined abscess there is good reason to assume that its drainage by costo-transversectomy will suffice. As to which side of the abscess should be approached some indication may be given by studying the radiograph and selecting the side whose lateral abscess shadow is the greater or, if the lateral shadows are equal, the side with the more profound paralysis, if there is any difference between the two sides. Should there be little evidence of an abscess or if it is small, antero-lateral decompression is probably indicated. Should it be found, during an antero-lateral decompression operation, that on removal of rib and transverse process an abscess with thin fluid pus is revealed it may be wiser to be content with a costo-transversectomy rather than perform a complete decompression and run the risk of tuberculous meningitis. It is well to remember that although the local obstruction may be removed by decompression the very procedure adopted for its removal may permit of a trickle of pus along the canal well beyond the natural barrier which had been formed before the operation.

Good lateral radiographs are essential so that the precise site and cause of obstruction may be determined as far as possible (Fig. 9). It is also important that the centre of the operation incision should be at the focal point of pressure. Often a patient with paraplegia of acute onset has no deformity and counting of the spinous processes is unreliable. The pressure site can be ascertained by taking a linen strip bearing a row of metal rings spaced three-quarters of an inch apart and fastening it by an adhesive to the skin over the spinous processes; the uppermost ring at vertebra prominens. A radiograph is taken and the ring nearest the point of obstruction noted (Fig. 10). At the operation the ring strip, sterilized by boiling, is held over the spinous processes as before and the level of the selected ring is marked on the skin with methylene blue.

Every patient who has recovered from paralysis should have a spinal fusion; this is particularly urgent for the patient who has had an antero-lateral decompression. The ring strip will be found helpful in plotting precisely the vertebrae that are to be grafted. It is not an uncommon experience that a radiograph after operation reveals a vertebra that the graft has missed or a vertebra grafted without intention.

CHEMOTHERAPY

Hitherto tuberculosis as it affects skeletal structures alone has been considered, but one should keep constantly in mind that a tuberculous bone or joint is a blood-borne metastatic focus of a primary disease elsewhere, particularly of the lungs and mediastinal glands. This fact was well proved by K. J. Mann in an investigation of five hundred patients with skeletal tuberculosis at Stanmore. He found that 57 per cent had active pulmonary disease. Chest radiography in skeletal tuberculosis is therefore important. It is worth recording that both at Stanmore and at Glan Ely it is now rare to find skeletal tuberculosis from infection by the bovine bacillus. The problem of infection is therefore mainly one of contagion between human beings.

The tuberculous invasion of a joint probably begins at the synovial membrane, a tissue comparable to the lining membrane of the thoracic and abdominal cavities where tuberculosis may declare itself as a pleurisy or peritonitis. A tuberculous joint beginning as a synovial membrane invasion may reveal itself clinically by synovitis, pain, heat and muscle contracture; the radiograph shows osteoporosis. In whatever organ or tissue tuberculosis may appear it is but one disease. Ever since Robert Koch in 1882 discovered the tubercle bacillus to be

the cause of scrofula and phthisis, thereby proving their unity, it has been felt that the ideal remedy would be that which would destroy the invading micro-organism in the living. The discovery by Waksman of streptomycin in 1943 was the first important step in this direct attack on the bacillus. Nine years later, in February 1952, Marcus Kogel of New York announced that a drug, isonicotinic acid hydrazine, an isomer of niacin (a member of vitamin B complex group), had been prepared and tried out on patients with advanced tuberculosis of the lungs at Seaview Hospital. The reaction of the patients to the drug was favourable; their pyrexia decreased and their appetite and sense of well being improved. The drug, now

FIG. 9

FIG. 10

Identification of diseased vertebrae. Figure 9.—Lateral view of spine showing destruction of the fifth, sixth and seventh thoracic vertebrae with collapse and angulation at the sixth vertebra in a patient with paraplegia. Figure 10.—A linen ring strip was fixed over the spine with adhesive tape, with the uppermost ring at the vertebra prominens. The sixth ring was over the most collapsed vertebra and served to identify it. At operation the sterilized ring strip was held in place by hand and by skin marking at the sixth ring the site of spinal cord pressure was determined.

known as isoniazid, has been given an extensive trial in many hospitals in this country under the guidance of the Medical Research Council.

Streptomycin has proved its value in all manifestations of tuberculosis, probably by producing an inhibitory or bacteriostatic action on the tubercle bacillus. But a primary focus in the chest may be walled off by an avascular capsule of fibrous tissue and be inaccessible to any drug, the bacilli sleeping indefinitely unless some circumstances rouse them to activity. Again the bacillus can, like other bacteria, become resistant to an antibiotic; the resistance however is diminished by the administration of sodium para-amino salicylate (P.A.S.) with streptomycin. In the treatment of skeletal tuberculosis at Glan Ely Hospital it has been the practice to give an adult patient one gramme of streptomycin and fifteen grammes of P.A.S. daily for ninety days followed by an interval of a month during which no drug is given. After this rest period drug treatment is resumed for another ninety days so that 180 grammes of streptomycin are given in all. The experience of the use of

streptomycin is similar to that recorded at other hospitals; it retards the destructive process of the disease, hastens reossification and shortens the duration of the malady. An average length of time for conservative treatment of intra-articular disease of the hip combined with streptomycin and P.A.S. is about twelve months as compared with twenty months without an antibiotic. Furthermore earlier quiescence of the disease allows a fusion operation sooner if such is contemplated. But before arthrodesis is undertaken there should be an interval during which no antibiotic is given, thereby diminishing drug resistance by the micro-organism and helping to make the resumption of streptomycin with isoniazid or P.A.S., immediately before operation, more effective in its protection in the post-operative period.

The Medical Research Council report of clinical trials on the use of isoniazid in pulmonary tuberculosis affirms its value in improving the general condition of the patient as judged by gain in weight, fall in temperature and reduction of blood sedimentation rate. But resistance to the drug is rapidly established over a three-months period of administration. It should therefore never be given alone; combined with a small quantity of streptomycin its bactericidal power is considerably increased because of the diminished resistance of the tubercle bacillus thereby induced.

The limited experience with isoniazid in combination with streptomycin in the treatment of skeletal tuberculosis has so far produced a similar improvement in the general condition of the patient to that already reported about its use in pulmonary tuberculosis. It is tempting to combine isoniazid, streptomycin and P.A.S., the most powerful anti-tuberculous agent of all, but in so doing there is a disadvantage of having all eggs in one basket; if in such usage resistance does appear there is left no remedy against it. A more prudent plan is to give one gramme a day of streptomycin and 150 milligrams of isoniazid over a period of ninety days, rest for thirty days and resume again with streptomycin and P.A.S. alone. Whenever possible the same preliminary testing for drug sensitivity should be followed in the case of chemotherapy in tuberculosis as is already being done for the choosing of a suitable antibiotic in pyogenic infection.

When invasion of a joint is comparatively early and still confined to the synovial membrane, streptomycin may be expected to arrest further progress of the disease and prevent bone erosion with restoration of mechanical efficiency of the joint. In this clinical type the limb may have no splint, the patient performing such active movements of the diseased joint as recumbency will permit. The very young can be controlled and movement restrained sufficiently by applying a plaster-of-paris cast on the sound side from waist to mid-calf.

But when bone is already eroded the joint should be immobilised by splinting in order to limit the area of disruption. A broken articular surface usually ends in a stiff joint on recovery and is a potential source of osteoarthritis. A natural bony ankylosis may be the best outcome, for it ensures an absolute cure of the local disease and a comfortable useful limb. When the articular surfaces of a joint are destroyed and the acute or progressive stage of the disease is over, as revealed by commencing bone recalcification, it is possible to perform a fusion earlier by operating under a streptomycin protection. This applies particularly to the knee joint.

Streptomycin and other antibiotics are of great value in the treatment of a tuberculous sinus, for it allows local application of the drug. For the rational treatment of a chronic sinus a knowledge of the prevailing micro-organism and its sensitivity is important. A culture from a swab of the sinus exudate will reveal the predominant micro-organism. The antibiotic to which it is least resistant is packed into the sinus and the mouth sealed with collodion gauze. The same procedure is repeated daily whilst the patient is put on a course of streptomycin and P.A.S. If tubercle bacilli are grown from the swab streptomycin is also applied locally to the sinus but no other antibiotic. Occasionally antibiotic and surgery are indicated.

To support chemotherapy in its attack on the invading bacillus it is desirable that pools

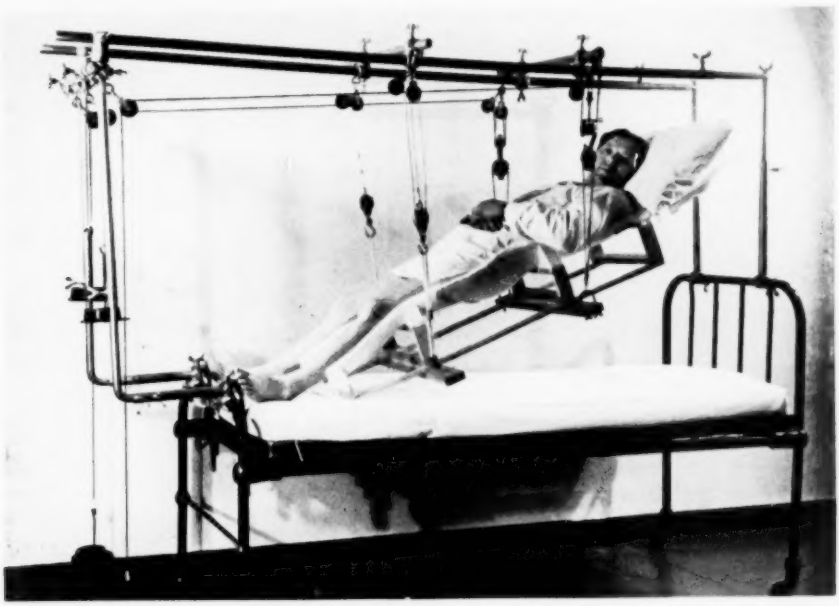

FIG. 11

Mr E. J. Nangle's suspension apparatus. It will allow suspension in any plane of a patient in a plaster bed or abduction frame. Elevation and adjustment are easily controlled by the patient. His visible field is extended; feeding, nursing, and occupational therapy are easier. Parts remote from the site of disease can be given exercise and there is much less tendency to develop renal calculi.

of infection should be evacuated, if reasonably possible without menace to the patient. All accessible abscesses should be aspirated. Sometimes a deeply hidden focus of infection may send out recurring metastatic deposits. This applies particularly to primary infection of mediastinal glands where the defensive barrier is inadequate.

The application of chemotherapy for the cure of tuberculosis is a very great advance but the need for increasing the natural resistance of the patient to the disease should not be neglected. Rest, fresh air, good feeding and every means of promoting the contentment of the patient must be maintained (Fig. 11). Rest itself is important in reducing toxaemia.

Tuberculosis in its pulmonary and crippling skeletal manifestations has been a scourge of the Western World throughout the centuries. The literature of the middle ages makes gloomy reference to the King's Evil. The number of the men of talent alone who have died young because of this foul disease is appalling. But at long last, by wise legislation, education, temporary isolation and a specific therapy the disease is on the wane. The struggle has been hard, long and costly but to see the enemy in retreat is one of the rare exhilarating episodes reserved for our generation.

It is a pleasure to acknowledge with gratitude the great help given me by my colleagues, Dr V. Emrys Jones and Mr D. J. Martin. I also thank Mr Dillwyn Evans, Mr Dillwyn Thomas and Mr K. I. Nissen for readily allowing me the use of the case notes of patients under their care. I am also very appreciative of the skill shown by Mr R. W. Matthews in his drawings and of Mr R. J. Whitley in his photography.

PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

ROYAL GRANT OF ARMS

The British Orthopaedic Association has had the privilege of receiving a Royal Grant of Arms with the authority of the Garter Principal King of Arms, Clarenceux King of Arms and Norroy and Ulster King of Arms. A copy of the Grant is reproduced on the opposite page. It declares "That the affairs of the Association are managed by an executive committee consisting of the President, the Vice-President and certain other elected Officers and Fellows of the Association. That the said executive committee is desirous that Armorial Bearings should be assigned for the said Association with legal authority and he, as President, hath requested the favour of His Grace's Warrant for Our granting and assigning such Arms and Crest and in the same Patent such Supporters as may be proper to be borne and used for the British Orthopaedic Association on Seals, Shields, or otherwise according to the Laws of Arms."

The transcript of the last part of the Grant reads "Know ye therefore that We the said Garter, Clarenceux and Norroy and Ulster in pursuance of His Grace's Warrant and by virtue of the Letters Patent of Our several Offices to each of Us respectively granted do by these Presents grant and assign the Arms following for the British Orthopaedic Association that is to say:—Azure a Scamnum between two Cords nowed Or on a Chief paly of four Gules and Gold a Lion passant guardant counterchanged And for the Crest On a Wreath of the Colours On a Mount Vert a young Plane tree in leaf with a crooked stem bound with Cords to a straight Post on the dexter all proper as the same are in the margin hereof more plainly depicted. And by the Authority aforesaid I the said Garter do by these Presents further grant and assign the Supporters following for the British Orthopaedic Association that is to say:—On the dexter side a representation of Hippocrates habited Azure supporting with his exterior hand a Ladder from which a rung has been removed and on the sinister side a representation of Aesculapius habited Argent supporting with his exterior hand his Staff all proper as the same are also in the margin hereof more plainly depicted the whole to be borne and used for ever hereafter for the British Orthopaedic Association on Seals, Shields or otherwise according to the Laws of Arms."

There is historic tradition in the scamnum which was used in the treatment of fractures and dislocations two centuries ago.[1] Even the knots on each side of the scamnum have been reproduced with accuracy from early Hippocratic illustrations. The ladder held by Hippocrates as supporter on the dexter side has one rung removed, as it usually was removed in this treatment for dislocations of the shoulder so that the patient would not break his neck.[2,3] Aesculapius with rod and serpent is supporter on the sinister side. The crest is a tree with twisted trunk bound to a straight post, copied from Andry's *Orthopaedia*—probably the first published volume on the prevention and correction of deformity. We have made it a plane tree because it was beneath a plane that Hippocrates stood at Cos to teach his disciples. The mount below includes the English rose, the Welsh daffodil and the Scottish thistle—but we are proud to know that this emblem is now also incorporated in the Presidential badges of our fellow associations in the United States, Canada, Australia, New Zealand and South Africa, with an American eagle, a maple leaf, a spray of wattle, a kowhai flower and a giant protea respectively. The motto on the British grant of arms is the single word *Recte* which is to be translated not only as straightly but as uprightly—befitting, proper and good.[4]

[1] GRIFFITHS, D. LL., and BROCKBANK, W.: "Orthopaedic Surgery in the Sixteenth and Seventeenth Centuries. Traction Apparatus—the Vidian Pictures." Journal of Bone and Joint Surgery, 1949, **31-B**, 313.

[2] GRUCE, J. A. De: Officina Aurea d.i. Guldene-Werck Statt der Chirurgy Oder Wundt-Artznay (Frankfort am Meyn), 1607.

[3] BROCKBANK, W., and GRIFFITHS, D. LL.: "Orthopaedic Surgery in the Sixteenth and Seventeenth Centuries. Luxations of the Shoulder," Journal of Bone and Joint Surgery, 1948, **30-B**, 370; and "Luxations of the Hip," Journal of Bone and Joint Surgery, 1950, **32-B**, 277.

[4] WATSON-JONES, R.: Journal of Bone and Joint Surgery, 1952, **34-B**, 489.

To All and Singular

to whom these Presents shall come the Honourable Sir George Rothe Bellew Knight Commander of the Royal Victorian Order Garter Principal King of Arms Sir Arthur William Stuart Cochrane Knight Commander of the Royal Victorian Order Clarenceux King of Arms and Sir Gerald Woods Wollaston Knight Commander of the Most Honourable Order of the Bath Knight Commander of the Royal Victorian Order Norroy and Ulster King of Arms Send Greeting Whereas Sir Reginald Watson Jones Knight Fellow of the Royal College of Surgeons President of the British Orthopaedic Association hath represented unto The Most Noble Bernard Marmaduke Duke of Norfolk Knight of the Most Noble Order of the Garter Knight Grand Cross of the Royal Victorian Order Earl Marshal and Hereditary Marshal of England and One of Her Majesty's Most Honourable Privy Council that the said Association was formed on the Second day of February 1918 for the advancement of the science and art of orthopaedic surgery That the affairs of the Association are managed by an executive committee consisting of the President the Vice Presidents and certain other elected Officers and Fellows of the Association And that the said executive committee is desirous that Armorial Bearings should be assigned for the said Association with legal authority and he as President hath requested the favour of His Grace's Warrant for Our granting and assigning such Arms and Crest and in the same Patent such Supporters as may be proper to be borne and used for the British Orthopaedic Association on Seals Shields or otherwise according to the Laws of Arms And forasmuch as the said Earl Marshal did by Warrant under his hand and Seal bearing date the Tenth day of May last authorize and direct Us to grant and assign such Arms and Crest and such Supporters accordingly Know ye therefore that We the said Garter Clarenceux and Norroy and Ulster in pursuance of His Grace's Warrant and by virtue of the Letters Patent of Our several Offices to each of Us respectively granted do by these Presents grant and assign the Arms following for the British Orthopaedic Association that is to say Azure a Saltorwise between two Cotises nowed Or in a Chief paly of four Gules and Gold a lion passant guardant counterchanged And for the Crest On a Wreath of the Colours On a Mount Vert a young Plane tree in leaf with a crooked Stem bound with Cords to a straight Post on the Sinister all proper as the same are on the margin hereof more plainly depicted And by the Authority aforesaid I the said Garter do by these Presents further grant and assign the Supporters following for the British Orthopaedic Association that is to say On the Dexter side a representation of Hippocrates habited Azure supporting with his exterior hand a Ladder from which a ring has been removed and on the sinister side a representation of Aesculapius habited Argent supporting with his exterior hand his Staff all proper as the same are also on the margin hereof more plainly depicted the whole to be borne and used for ever hereafter by the British Orthopaedic Association on Seals Shields or otherwise according to the Laws of Arms In witness whereof We the said Garter Clarenceux and Norroy and Ulster Kings of Arms have to these Presents subscribed Our names and affixed the Seals of Our several Offices This Seventeenth day of July in the First year of the Reign of Our Sovereign Lady Elizabeth the Second by the Grace of God of Great Britain Ireland and the British Dominions beyond the Seas Queen Defender of the Faith &c and in the year of Our Lord One thousand nine hundred and fifty-two

ROYAL SOCIETY OF MEDICINE

SECTION OF ORTHOPAEDICS

Presidential address—Mr H. Jackson Burrows delivered his Presidential address, "An Even Keel in Orthopaedics," on March 3, 1953. He recalled that not all complaints demanded treatment, and deplored the prompting "let's do something, even if it's wrong." Many patients came to the surgeon, not in search of treatment, but for a prognosis. Such were an easy prey to the unscrupulous. Parental anxiety, especially among the better-to-do, had created a demand for treatment which the profession had eagerly met. It was no longer possible to be a really nice little man without enduring the indignities of circumcision, tonsillectomy, shoe-wedging and "remedial exercises." The practice of fitting wedges to the shoes for knock-knee often, by promoting a varus foot, delayed a recovery that was almost inevitable if nothing were done. The "remedial exercises" so popular in schools avoided a plantigrade foot at all costs. There was need of a S.L.P.L.B.A.*

The abstraction "rest" was now less misused than in the past, but in poliomyelitis the intemperance of the reaction against misapplied rest had led to a violence that tortured patients, provoked spasm in unparalysed muscle and even caused myositis ossificans. The speaker believed that in muscle re-education after poliomyelitis insufficient attention was given to preserving the power of active relaxation of muscles not paralysed; early attempts to contract a paralysed muscle were useful because they made the unparalysed opponents relax. There was a need to return to physiological principles in the treatment of poliomyelitis, a subject in which there had been too much unphysiological "stunting"—and not only by Miss Kenny.

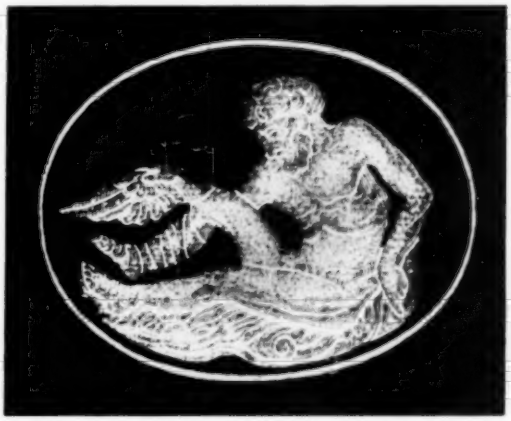

FIG. 1

Elevation and cooling (from Jacobson's edition of Hilton's Rest and Pain).

The campaign against passive movements that preceded the last war had effectively diminished their misuse; but overstatement had led to many stiff joints from neglect of passive movements when paralysis made active movements impossible. A neglected agent was the ice-bag for cooling the limb after an operation or other injury likely to lead to swelling (Fig. 1). Active exercises were the basis of nearly all physiotherapy. They—and especially their elaborations (Figs. 2 and 3), such as pulley exercises, occupational therapy and remedial games—could speed or delay recovery in accordance with their wise or unwise application. All would commend industrial rehabilitation units, as at Luton and Birmingham. A beautiful application of auto-assisted movement (Fig. 4) was Denis Browne's hobble splint, in which the infant's proclivity for marking time was applied to the correction of deformity. Most would differ from its initiator, however, in his use of forced manipulation. The value of gradual correction by re-splinting had been illustrated recently by Mr A. T. Fripp with his Kite plasters for club feet; and Dr E. E. Harris at the Heritage, Chailey, was using the principle for correction of many deformities by frequently renewed plaster splints. In spastic paralysis, the extent and duration of benefit conferred by a spell of splinting—notably calipers and wrist splints—was not recognised enough. In the flaccid paralysis of poliomyelitis restraint in the use of appliances in the child had been pleaded lately, but to unfetter the boy was often to fetter the man. This was a matter in which the most careful, unemotional judgment of each patient must be combined with the greatest vigilance.

Discussing orthopaedic operations, Mr Burrows deplored unnecessary surgery. A surgeon who subjected his patient to an operation that he would not allow in his own kin was guilty of a breach of faith. Usually a diagnosis of ruptured intervertebral disc should not dismay the patient, but it often did because it suggested to him the prospect of an operation of doubtful efficacy—his friends had had it. Removal of a displaced intervertebral disc in the exceptional and properly selected case was a great surgical advance, but it had been discredited by those who had found within the disc a glittering nugget of gold.

* Society for Leaving the Poor Little Blighters Alone.

Arthroplasty of the hip was another of the great advances of our time. Prosthetic femoral heads had been used successfully for only six years, still had many shortcomings, and should not be used unnecessarily in young people.

Referring to congenital dislocation of the hip, Mr Burrows thought that perhaps the dangers of radioscopic arthrography had been overlooked, reversion to operative reduction overdone, and the need for early rotation osteotomy underestimated.

Most of us had designed gadgets that we had later regretted. A recent tendency was to show confessedly unsuccessful gadgets in the spirit that it was better to have gadgeted and lost than

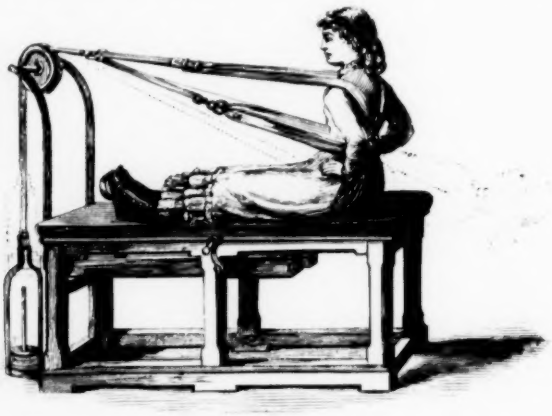

FIG. 2

Active exercise against resistance, A.D. 1883.

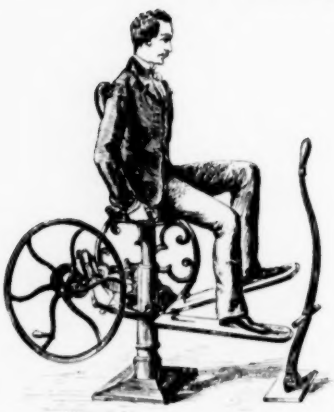

FIG. 3

FIG. 4

Figure 3—The velocipede. "The movements must be discontinued when fatigue is felt."
Figure 4—Auto-assisted movements—grace and languor.

never to have gadgeted at all. One application that had succeeded spectacularly was Key's compression arthrodesis of the knee, popularised by Charnley. When the knee was to be arthrodesed it should be fixed in considerable flexion, not in nearly full extension, whatever the patient's occupation. A patient with a stiff knee must sit on the forward edge of his chair in order to get his foot near the ground; with the knee fixed in 30 degrees of flexion he could sit back in his chair and his leg projected about half as far (Fig. 7). Moreover, in normal walking, weight was never taken on an extended knee. Thus there was no case for arthrodesis of the knee in the position of full extension.

Misapplied operation was exemplified by the orthopaedic epitaph: "he died in perfect position." A person who could sit but not stand had often been converted into one who could stand but not sit. It was common knowledge that, in poliomyelitis, ill-advised lengthening of the tendo calcaneus could condemn a patient to a caliper for life; but in spastic paralysis the operation might be far more devastating. The subject of bone operations upon growing feet was more controversial. The bad late results led to the conclusion that they were rarely, if ever, justifiable. Sometimes the worst handicaps did not obtrude, and it was important always to consider the whole patient, and, still more, the patient in his own surroundings, in assessing his true disability.

Too faithful a devotion to the cult of "no-touch technique" must not promote neglect of bigger things; there were occasions for the adage "put your finger in it or you'll put your foot in it."

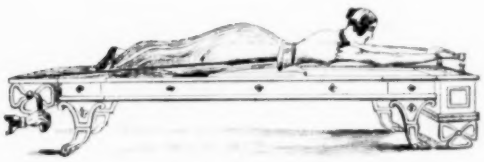

FIG. 5
Worth its weight in gold.

FIG. 6
Hospital model.

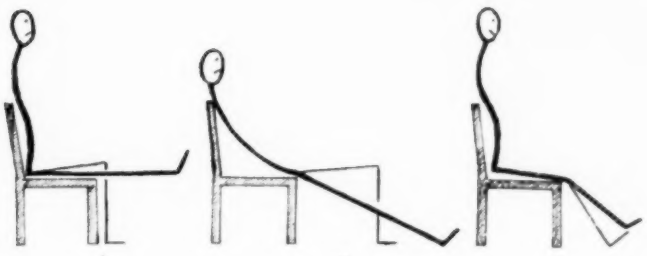

FIG. 7
Arthrodesis of the knee in extension and flexion. A and B—Sitting with knee stiff in extension. C—Sitting with knee stiff in flexion of about 30 degrees.

Mr Burrows concluded by considering the place of orthopaedics in medical education. Lambrinudi had emphasised that the principles of medicine as a whole could be demonstrated perhaps better in orthopaedic patients than in almost any other. There was a strong demand among students for this teaching, which offered unparalleled opportunities for: history taking; observation of physical signs; the synthesis of these in relation to anatomical and physiological principles; the testing of the provisional diagnosis by special methods of examination; the final summing up; and finally the lucid explanation to the patient. The undergraduate schools could not for ever live in the past and ignore or suppress the so-called special departments. There was a well defined place for distinct postgraduate schools with wide facilities for special experience, pathology and research. The extensive and stereotyped training that had been planned for our future colleagues and successors was perhaps too all-embracingly technological at the expense of serious experience in the basic sciences and methods of research and of that cultivation of individuality that was rightly called education.

UNIVERSITY OF LIVERPOOL

M.CH.ORTH. EXAMINATION

Of the postgraduate students who have worked in Liverpool during the last year those who gained their M.Ch.Orth. degree in December 1952 are: Colin Conacher, Sydney, Australia; Wilfred C. Lawrence, Litchfield, England; Manuel Lunz, Johannesburg, South Africa; Robert Page, Ottawa, Canada; Abdul Rahim, Lahore, Pakistan; Eric H. Strach, Prague, Czechoslovakia; J. G. Stubbs, London, England; and Kenneth J. M. Watson, Brisbane, Australia. The two external examiners were Professor Walter Mercer and Mr Jackson Burrows, and the three internal examiners were Mr Norman Roberts, Mr Eric Wardle and Professor B. L. McFarland.

UNIVERSITY OF OXFORD

NUFFIELD ORTHOPAEDIC CENTRE

Forthcoming lectures—Lectures to be delivered at the Wingfield-Morris Orthopaedic Hospital include: "The Vasculature of Bone and the Healing of Fractures—an Experimental Study," by Dr A. X. Cavadias, on May 28; and "Solitary Fibro-osseous Lesions of Bone and their relation to Fibrous Dysplasia," by Dr H. L. Jaffe, on June 11. Both lectures begin at 8.30 p.m.

REGIONAL ORTHOPAEDIC CLUBS

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting of the East Anglian Orthopaedic Club was held at Addenbrooke's Hospital, Cambridge, on November 29, 1952. Clinical cases were shown.

Atlanto-axial dislocation—*Mr B. J. S. Grogono* demonstrated the normal anatomy of the joints between the atlas and axis. In a dissected specimen and with radiographs he showed the variations with age and position between one patient and another. He reviewed seven cases of atlanto-axial dislocation, some caused by injury, and some associated with naso-pharyngeal infection. Treatment was by plaster or plastic collars, or by wiring and local fusion. A discussion followed in which some members spoke of the success that seemed to attend almost casual treatment of this condition. The rarity of neurological signs was commented upon and the general feeling seemed to be that operation was indicated only in cases of recurrent dislocation or when there were associated neurological signs. Mr Grogono also showed a specimen taken from the spine of a man who had died after a road accident. He had had paraplegia and the specimen showed tearing of two intervertebral discs with narrowing of the spinal column between them. A section of the cord in this area showed haemorrhage into the lateral columns.

Fractured femur with traumatic aneurysm—*Mr R. Dee* showed radiographs of the femur of an elderly woman with spiral fracture of the femur at the junction of the middle and lowest thirds. There was no palpable arterial pulsation below the level of the fracture and the thigh was very swollen. a systolic murmur was heard over the swelling. A traumatic aneurysm was diagnosed. Hunterian ligation was carried out and she slowly recovered. Although theoretically this might seem to be a likely complication of fractures at this site, no member present had had a similar experience.

Schmorl's nodes—*Mr R. W. Butler* discussed the significance of Schmorl's nodes. He said that although they were generally claimed not to be the cause of symptoms, he had encountered cases in which it was hard not to attribute the patient's symptoms to the nodes. He pointed out that the antero-posterior diameters of the affected bodies as seen in the lateral radiographs were longer than those of the adjacent bodies, that the nodes were commonly seen in the upper lumbar region and were not seen in old people. An interesting discussion seemed to indicate that there was room for much further investigation.

Osteitis of pubis—*Mr Murray* demonstrated the films of a man who had osteitis of the pubis after appendix abscess, shown to the club in January 1950. The serial radiographs showed gradual recalcification and eventual sclerosis of the pubis and some irregular ossification round the tuberosity of the ischium. *Mr G. K. McKee* showed radiographs of a similar case after prostatectomy. In the discussion members spoke of the cases they had seen after prostatectomy—especially after Millin's operation—but only one other case of pubic osteitis complicating appendicitis was mentioned.

Osteomyelitis of fibula—*Mr J. Fairbank* showed a child aged seven years with uneven growth in the lower leg after osteomyelitis of the fibula. The lower end of the fibula had been removed and the ankle assumed a valgus deformity. This was corrected by osteotomy of the tibia; the stump of the fibula was fixed to the tibia. Correction was satisfactory at first but in the next year growth

continued to be uneven and the foot was assuming a valgus position again. Various suggestions were made, including stapling of the medial side of the tibial epiphysis so that continued growth would not push the talus out of the ankle mortise.

Paget's disease—*Mr Dee* showed a case of arthrodesis of the knee in a patient with Paget's disease of the femur. Now that the femur and tibia were continuous he wondered whether the disease would spread into the tibia. As judged from radiographs, sound bony union had taken two years to occur. Others spoke of their experience of slow bony union in Paget's disease.

Fractured femora—*Mr L. W. Godfrey* showed a patient who had sustained fractures of both femora treated at one operation by medullary nailing. Seven weeks after operation he was bearing weight with crutches, and had good knee movements.

Rheumatoid arthritis and gout—*Mr Murray* demonstrated the differences apparent radiologically in the hands of patients with rheumatoid arthritis and gout. He emphasised the difference between the small areas of osteoporosis that sometimes broke the joint line in rheumatoid arthritis and the punched-out areas of calcium bi-urate, deep from the joint line, that were seen in gout.

Congenital absence of upper femur—*Mr Noel Smith* showed a patient with congenital absence of the upper part of the femur. Radiographs showed a head of the femur and a tapering lower end. The girl had been fitted with a patten-ended caliper, but this was not very satisfactory through the lack of a greater trochanter. There was now five inches of shortening. Members were asked for suggestions and it was generally agreed that bone grafting should be delayed until growth ceased and that in the meanwhile every effort should be made to encourage the use of the limb.

SOUTH AFRICA

SOUTH AFRICAN ORTHOPAEDIC ASSOCIATION

ANNUAL MEETING

The annual meeting of the South African Orthopaedic Association was held in Johannesburg from September 23–26, 1952, under the presidency of Mr G. T. du Toit. The secretary, Mr W. T. Ross, reported that membership of the Association had increased from thirty-eight members in 1951 to forty-five in 1952.

Orthopaedic aspects of chronic arthritis—*Mr S. Sacks* dealt comprehensively with the means of treatment at our disposal, such as rest, traction, splintage, manipulation, intra-articular injections and the various types of surgical operations. In discussion, *Mr Hamilton Bell* pleaded for more co-operation with the physicians, especially in the early stages when much deformity could be prevented. *Mr C. Morris* suggested that when hydrocortone was injected into joints, a radio-opaque substance should be injected with it to show whether it really was in the joint. This applied especially to the hip joint. *Mr H. I. Maister* recommended correction of knee deformities in rheumatoid arthritis by the application of a light Thomas splint, to which the limb was bandaged. The splint was bent a little each day until the desired correction was obtained. He also stated that the pain in arthritic knee joints could often be relieved by simple joint lavage with normal saline to wash out fibrinous deposits.

Cervico-brachial neuritis—*Mr R. N. Houlding* of Rhodesia described his findings in sixty-five cases. Symptoms included pain in the neck, headaches, torticollis and cutaneous hyperaesthesia in the arm or hand, and weakness of grip. He thought the symptoms were due to disc protrusion from relaxation of the posterior common ligament when the neck was forcibly extended from a flexed position. The slowly progressive cases might be due to disc oedema. Relief of symptoms was obtained in sixty-two of the sixty-five cases by manipulation under anaesthesia followed by head traction (five pounds) for one to seven days. Operation was required in three cases. It was stressed that accurate localisation of the level by clinical and radiographic examination was essential. A small bone graft was placed under mild compression between the two spinous processes contiguous with the affected disc space so as to open up the disc space posteriorly. Behind this graft two longer grafts were placed on each side of the spinous processes and fixed together with a single screw. Good results were claimed.

British and continental orthopaedic surgery—A report was given by Messrs J. M. Edelstein, G. T. du Toit, C. J. Kaplan, G. Dommisse and W. T. Ross, all of whom had recently returned from overseas. This proved to be one of the high-lights of the meeting, and the audience was fascinated by a description and demonstration of recent trends in orthopaedics, including many new operative tricks and gadgets. It is noteworthy that the field to be covered included so much that none of the speakers overlapped on any of the subjects seen in their travels, which ranged from Edinburgh to Florence!

Clinical Meeting

A clinical meeting was held in the Medical School of the Witwatersrand University.

Ewing's tumour—*Mr B. Polonsky* showed a case of Ewing's tumour in the upper end of the femur of a girl aged nine years, first diagnosed in 1948. It had been treated by deep x-ray therapy, but recently spontaneous fracture had occurred. No other deposits had been found elsewhere in the body. Unfortunately the parents' consent could not be obtained for any operation except a biopsy. It was felt that amputation at an early stage might have proved effective.

Ischio-femoral arthrodesis—*Mr Polonsky* also showed a successful ischio-femoral arthrodesis for tuberculous arthritis of the hip in which a massive strut of bone had formed along the line of the graft. *Mr G. T. du Toit*, while complimenting the surgeon on the good result obtained, stressed that this was not hypertrophy of the graft in the true sense of the term, but ossification around the graft.

Osteoclastoma of radius—*Mr W. T. Ross* showed a woman of thirty-five years, the distal four inches of whose radius had been excised for osteoclastoma and replaced by the upper end of the fibula. Fourteen months after operation the result was excellent; she had a strong painless wrist, with fifty-five degrees of movement. Mr Ross thought this was the method of choice in this condition, although degeneration of the articular cartilage on the graft seemed inevitable in the absence of a nerve supply. He was not satisfied with the results of deep x-ray therapy or curettage plus bone chips.

Rupture of extensor pollicis longus—*Mr W. T. Ross* showed a middle-aged woman who had ruptured the long extensor tendon of her thumb fourteen years before, after a Colles fracture. Inability to "let go" when shaking hands, and diminished rotation of the forearm, had been embarrassing and disabling. At operation the extensor indicis tendon was transplanted into the distal end of the extensor pollicis longus, and the lower end of the ulna was excised. Six months later she had full function of the thumb and wrist. Mr Ross thought extensor indicis was a more suitable tendon to use than extensor carpi radialis longus or brevis, or extensor pollicis brevis.

Other cases—*Mr C. Morris* showed a Bantu male child aged two years with swelling of the right foot and wasting of the right thigh and leg. A limp was present. Radiographs showed changes in the metatarsals, talus, tibia, fibula, femur and pelvis. These changes were compatible with a diagnosis of multiple cystic tuberculosis, which was confirmed by biopsy. *Mr J. M. Edelstein* showed a patient in whom an ilio-femoral arthrodesis had been performed nearly twenty years ago by Mr Seddon in London for tuberculous arthritis. The result was excellent. Recently the patient had developed tuberculous infection of the elbow, and excision of the elbow had been performed by the Kirkaldy-Willis technique with a good result. *Mr G. T. du Toit* showed a case of paralytic scoliosis, in a boy aged fourteen years, with marked pelvic tilt. The mechanics of the deformity and the possible methods of treatment were discussed at length.

Officers for 1953—Mr F. P. Fouché was elected emeritus president and Mr G. T. du Toit president. Other officers are: secretary, Mr W. T. Ross; executive members—Messrs J. M. Edelstein, C. T. Moller and J. G. du Toit.

ITALY

ITALIAN SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

Annual meeting—The thirty-seventh annual meeting of the Italian Society of Orthopaedic and Traumatic Surgery was held in Genova from October 6–8, 1952, at the Simon Boccanegra's Castle, in St Martin's Hospital, under the presidency of Professor R. Zanoli. The principal subject discussed was paralytic shoulder. An official report on this subject was presented by Drs F. Roasenda and A. Strata. On this same subject forty-one papers were presented. The second subject discussed was periarthritis of the shoulder. An official report on this subject was presented by Professor A. Bonola. The meeting was attended by many eminent orthopaedic surgeons from other countries, including Professor H. Platt (Great Britain), Professor M. Lange, Professor L. Böhler, Professor C. Mau, Professor G. Hohman, Professor S. Weil, Professor K. Niederecker, Professor Kreisel, Professor Hackenbrock (Germany), Professor Etienne, Professor Perrot, Professor Pereau, Professor J. Creyssel, Professor J. Herbert, Professor J. Forestier (France), Professor V. Sanchis-Olmos (Spain), Professor Contargyris (Greece).

Programme for 1953 meeting—The thirty-eighth meeting of the Italian Society of Orthopaedic Surgery and Traumatology will be held in Rome in October 1953 under the presidency of Professor Carlo Marino-Zuco. The principal subject for discussion will be post-traumatic joint stiffness. Papers and discussions on this subject are invited and should be submitted before July 10. Papers on other subjects will also be considered. Headsets for the reception of simultaneous translations in English, French and German will be available.

AUSTRIA

ORTHOPAEDIC AND TRAUMATOLOGICAL ASSOCIATION OF AUSTRIA

1952 meetings—In March 1952 a clinical demonstration was held. The use of ultra-sonic waves in orthopaedic surgery was discussed. In May 1952 an international meeting was held in Sonnenheilstatte Stolzalpe; the main subject for discussion was bone and joint tuberculosis. At a further meeting in December 1952 the main subjects discussed were surgical appliances and the use of plastic endoprostheses.

Officers for 1953—Professor Erlacher was re-elected president of the Association for 1953.

New rehabilitation centre—On May 24, 1952, the Sonderstation Tobelbad, a rehabilitation centre near Graz, financed by a leading insurance company, was opened by Korner, the President of Austria. The centre caters for the rehabilitation and resettlement of injured patients and has special facilities for the treatment of paraplegics and amputees. The clinical directors are Dr W. Ehalt and Dr Neubauer.

ECUADOR

ECUADORIAN SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

In September 1952 the Ecuadorian Society of Orthopaedic Surgery and Traumatology was founded in Guayaquil with Dr Eduardo Alcivar as president. The vice-president is Dr Gabo Ballesteros and the secretary Dr Jaime Barredo.

BRAZIL

CONGRESS OF ORTHOPAEDIC AND TRAUMATIC SURGERY

The congress of orthopaedic and traumatic surgery for 1953 will be held in Rio de Janeiro from July 19–26. Communications should be addressed to the secretary at Praça Floriano, 31–3o andar-sala 303, Rio de Janeiro.

INTERNATIONAL SOCIETIES

INTERNATIONAL SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

The Sixth Congress of the International Society of Orthopaedic Surgery and Traumatology will be held in Berne, Switzerland, from August 30 to September 3, 1954, under the presidency of Sir Harry Platt.

Officers—The honorary president of the congress will be Professor R. Scherb, of Zurich, and the president of the congress will be Professor Et. Sorrel, of Paris. All correspondence regarding the participation as well as the scientific part of the congress (reports, discussions and personal communications) should be addressed to the secretary-general of the Society, Dr J. Delchef, M.D., 34 Rue Montoyer, Brussels, Belgium.

Provisional programme—The provisional programme is as follows: *First day* (Monday, August 30, 1954)—08.30, Meeting of the International Committee; 11.00, official opening of the Congress; 14.00, scientific meeting; presentation of the first subject: treatment of scoliosis; 17.00, departure for dinner in the Bernese Countryside. *Second day* (Tuesday, August 31, 1954)—09.00–11.00, Scientific session; discussions and individual communications; 11.00, general meeting; 15.00–18.00, Scientific session. *Third day* (Wednesday, September 1, 1954)—Visits to different Swiss Hospitals and Institutions in groups: Berne—Isle-Hospita and Macollin—Federal School of Athletics (clinical demonstrations, communications, symposium on physiology of movement). Zurich Hospitals (clinical demonstrations; symposium on joint pathology). Basle Hospitals

(clinical demonstrations; symposium on chemical aspects in orthopaedic surgery). Lausanne Hospitals and Leysin Sanatoria (clinical demonstrations; symposium on joint and bone tuberculosis). Geneva Hospitals (clinical demonstrations; symposium on bone pathology). Jungfraujoch: Alpine research centre. Return to Berne in the evening. *Fourth day* (Thursday, September 2, 1954)—09.00–12.00, Scientific session; presentation of the second subject: surgery of the hand; 15.00–18.00, Scientific session; 20.00, official banquet. *Fifth day* (Friday, September 3, 1954)—09.00–13.00, Scientific session; individual communications. In the afternoon: closing of the Congress.

Participation at the Congress—Members of the Society: free of charge. Other participants: Swiss Francs 40.

Excursions—Further excursions will be arranged at the end of the Congress. Apply to the Congress Office, Kursaal-Berne, during the Congress.

Local organising officers—*Vice-president of the Congress* and responsible for the co-ordination of the organisation: Professor M. Dubois, Inselspital, Berne. *Collaborator:* Dr Hausammann, M.D., Inselspital, Berne. *Treasurer of the Congress:* Professor H. Debrunner, Burgerspital, Basle. *Secretaries of the Congress:* Professor M. R. Francillon, Balgrist, Zurich, Professor Ch. Scholder, Hospice orthopedique, Lausanne, and Mr A. Perrot, M.D., Hopital Gourgas, Geneva.

CORRESPONDENCE

DEAD BONE GRAFTS IN ORTHOPAEDIC SURGERY

From Professor H. L. Rocher, Bordeaux, France

To the Editor of the Journal of Bone and Joint Surgery.

Sir,

In 1946 I presented at the French Congress of Surgery my experiences with the use of dead bone in orthopaedic surgery, prepared according to the method of my son, Dr Christian Rocher. The technique was first described by my pupil, Leon Dorriotz (Utilisation de L'Os Mort Humain Conservé en Chirurgie Orthopédique de Reconstruction, 1939. Bordeaux: Imprimerie Bière), who referred to sixteen cases, the earliest being in 1937. I thought it would be interesting to your readers

Fig. 1

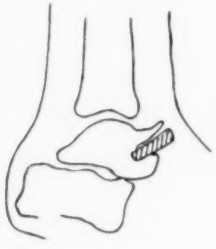

Fig. 2

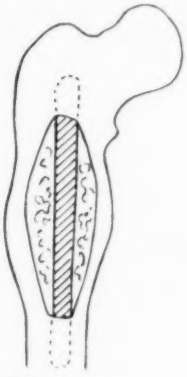

Fig. 3

Use of cadaveric bone grafts for shelf operation, formation of a bone block, and filling of bone cavity.

to compare this method with that recently published in the *Journal of Bone and Joint Surgery* (Experiences with Boiled Cadaveric Bone. Journal of Bone and Joint Surgery, **34-B**: 429).

The bone is removed from amputated limbs. The soft tissues and the periosteum are cleaned off and the articular cartilage is removed. The bone is then boiled for three hours to clear thoroughly all the soft tissue from the marrow cavities. After this preliminary boiling the bone is cut into blocks of suitable size and shape for use as grafts, some being of compact bone and some

of cancellous bone. The grafts are then boiled again for a further three hours to complete their extraction and are stored in 95 per cent alcohol. When the grafts are required for use they are sterilized together with the instruments.

These grafts are well tolerated. They become incorporated in the bony bed in which they have been placed. Experience shows that fusion of the graft with its host becomes complete. Within a year or so the fusion is so intimate that it is impossible to distinguish between graft and host.

In one case in which a graft was used in an operation for congenital subluxation of the hip the graft was absorbed. This failure was attributed to inadequate blood supply, for the graft was placed between the articular cartilage and the surrounding bone.

The dead graft performs two functions, mechanical and osteogenic. The mechanical property is used, for example, in the formation of an acetabular buttress, in the construction of a bone block, or in the repair of a pathological fracture occurring in a bone cyst or a giant-cell tumour after irradiation (Figs. 1 to 6). In the first two instances I insist on firm and deep implantation of the graft beneath the osteoplastic buttress raised by the gouge, thus making the transference of living cells

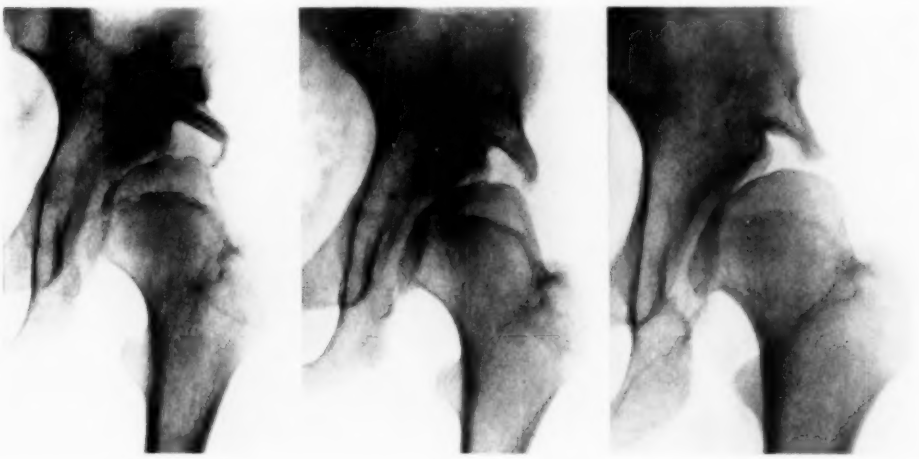

FIG. 4 FIG. 5 FIG. 6

Use of cadaveric bone graft in shelf operation. Figure 4.—Soon after operation in child of twelve. Figure 5.—Six months later. Figure 6.—Ten years later.

easy between the dead graft and its living bony pedicle. Close contact ensures the stability of the graft. The osteogenic function is seen in the packing of a bone cavity. The cavity should be filled with compact and cancellous bone which should be hammered firmly in with a punch.

I no longer use dead bone for fusion of the spine in Pott's disease or for arthrodesis of the hip. I find an autogenous tibial graft quite satisfactory. Furthermore, bridging a gap with dead bone seems to me a risky procedure.

Since Dorriotz's paper and my communication to the Surgical Congress my pupils and I have come to regard dead bone as an economical and easy method of grafting for shelf operation, bony cysts, arthrodeses and pseudarthrosis and we have experience of over 200 cases. Lloyd-Roberts's paper gives us hope that cadaveric bone may also be used to speed up consolidation in an arthrodesis which is progressing slowly. In my experience a dead graft should not be used unless it is in contact with living bone. This contact guarantees success provided the bed for the graft is properly constructed. Loss of a graft is most unusual and it indicates a fault in operative technique.

Yours very truly,

December 1952 H. L. ROCHER.

The coloured portrait of Her Majesty the Queen facing the first page of this issue is by Karsch of Ottawa, and it is published by permission of the Secretary of the Privy Purse.

Book Reviews

BULLETIN OF THE HOSPITAL FOR JOINT DISEASES. A Volume in Tribute to Dr Henry L. Jaffe, with 55 Contributors. Volume 12, Number 2, October 1951. 9 × 6 in. Pp. xiv + 527, with numerous figures. 1951. New York: Hospital for Joint Diseases. Price $6.00

Dr H. L. Jaffe is well known both to pathologists and orthopaedic surgeons from his research and writings on benign tumours of bones and joints. He and his collaborators have given us the "definitive" and often the original accounts of a number of important entities, including "osteoid osteoma," "benign chondroblastoma of bone," "chondromyxoid fibroma," "pigmented villonodular synovitis," and "fibrous dysplasia of bone."

This issue of the Bulletin of the Hospital for Joint Diseases commemorates Dr Jaffe's twenty-five years as the Pathologist and Director of Laboratories of the Hospital. A biographical sketch of Dr Jaffe—written by the Editor of the Bulletin, Dr Samuel Kleinberg—prefaces the volume, which comprises thirty-four original papers covering a wide field. Pathological topics are well represented, but other subjects, including clinical orthopaedics, radiology and biochemistry, are included. The papers are the work of fifty-five distinguished contributors, from about as many laboratories and clinical departments, most of them in the U.S.A., and are written specially for the commemorative volume. A number appeared interesting and important to the present reviewer, including: "Some observations on the morphologic basis for the roentgenographic changes in childhood leukaemia," by R. H. Follis and E. A. Park; "The non-specificity of synovial reactions," by Mary S. Sherman; "Rheumatoid arthritis, by C. L. Pirani and G. A. Bennett; "Primary parathyroid hypertrophy and hyperplasia," by B. Castleman and O. Cope; "Benign chondroblastoma of bone," by C. H. Hatcher and J. C. Campbell; "New knowledge of postfetal osteogenesis," by F. C. McLean and M. R. Urist; "Physiopathology of bone tissue," by E. Rutishauser and G. Majno; and "Chondrodystrophia calcificans congenita," by W. G. J. Putschar. Such a list indicates the scope of the volume. The issue is a very fitting tribute to a man who has made, and who continues to make, such outstanding contributions to orthopaedic pathology.—H. A. Sissons.

Dr Henry L. Jaffe

ORTHOPADISCHE-CHIRURGISCHE OPERATIONSLEHRE. By Max Lange, Director of the Orthopaedic Hospital, Bad Tölz. 11 × 8½ in. Pp. xvi + 844, with 891 figures. Index. 1951. Munchen: J. Bergmann. Price DM.128.

Max Lange's text-book dedicated to his famous uncle, Fritz Lange, is a remarkable achievement. This monograph is essentially a work of reference for the experienced operator, who can take his pick of the various procedures which in one country or another have for a time at least become part of the orthopaedic surgeon's repertoire. Some of the operations depicted therein—the more elaborate tendon transplants, the muscle slides, and the intricate geometrical osteotomies—play a small part in British and American orthopaedic practice. But, in a work which is international in its outlook, this catholicity is to be applauded. The time and energy involved in producing a work of this scope, profusely illustrated with line diagrams and shaded pencil drawings, without any reference to photographs or x-ray reproductions, within six years of the end of the late war, is a striking tribute to the industry of German orthopaedics.—Harry Platt.

RECHERCHES MORPHOLOGIEQUES ET EXPÉRIMENTALES SUR LA VASCULARISATION OSSEUSE. By Robert de Marneffe. 9½ × 6½ in. Pp. 80, with 36 figures. 1951. Brussels: Acta Medica Belgica. Price not quoted.

This small book contains in its eigaty pages one of the best descriptions of the vasculature of the long bones based on the study of the vessels of the rabbit, guinea-pig and rat. Methods of arterial injection, including those of plastic material (Vinylite), are described, and the work is based on the analysis of this injected material, either directly or after the previous suppression of one or other of the three sources of blood to the bone. The author lays due emphasis on the part that the periosteal circulation plays in supplying the compact bone of the shaft and explains that no vessels appear to cross the epiphysial cartilage. He emphasises the existence of subchondral vessels and exhibits a nice illustration. He stresses the interest of this finding but does not seem to be acquainted with the work of Franceschini or of the Swedish School of Ingelmark and Holmdahl who have also found this close relationship between vessels and articular cartilage. A good description of the venous system in bone is given, but the lack of microradiography impedes the author from being as informative in describing the capillary plexus. No sinusoids appear to have been seen with the methods adopted, as there is no description of these most important structures. In spite of these criticisms and a slightly loose bibliographic section this may be considered the work which contains in the smallest number of pages the greatest available information on the circulation in the long bones.—J. Trueta.

RUPTURES OF THE ROTATOR CUFF. By H. F. Moseley, M.A., D.M., M.Ch. (Oxon.), F.R.C.S. (Eng. and C.), F.A.C.S. Hunterian Professor, Royal College of Surgeons of England; Assistant Professor of Surgery, McGill University; Associate Surgeon, Royal Victoria Hospital, Montreal, Quebec, Canada. 10½ × 8 in. Pp. xii + 90, with 108 figures, many in colour. 1952. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Price 47s. 6d.

This monograph in the American Lectures series is an expansion of the author's lectures as Hunterian Professor of the Royal College of Surgeons. The introduction, which pays tribute to Codman's work, is followed by a well and profusely illustrated chapter on the anatomy of the shoulder joint and its surrounding muscles.

The author has devised and described an inferior approach to the shoulder through the axilla. The rotator cuff is defined as the four muscles inserted into the humeral tuberosities and their conjoined tendons. The functions of this structure are controversial and some will disagree with the views put forward here. The degenerative changes that occur in the tendons and their insertion are well described and illustrated, and follow previous observations. The description of the clinical signs of rotator cuff tears and the method of examination to elicit them is excellent and might well be summarised in students' surgical text-books, which usually completely ignore this fairly common and disabling condition. The author believes that most tears requiring operative repair, both acute and chronic, can be diagnosed on clinical grounds alone, but is reluctantly prepared to wait in doubtful cases. He takes Codman's as opposed to McLaughlin's view and considers that delay prejudices the result of operation. The operative procedures in various types of tendon tear are well described. He gives short histories of his cases, and a satisfactory method of assessing results, and finds that his resemble McLaughlin's. The commonest disability after successful repair is a loss of power up to 30 per cent. The results of operation are better in acute cases than chronic ones, but, even in these, are much better than the results of conservative treatment. This is a valuable contribution to the literature of shoulder injuries and should be read by all who are, or ought to be, interested in the subject.—V. H. Ellis.

DYSTROPHIA MUSCULORUM PROGRESSIVA. By Herman Levison, Institute of Human Genetics, University of Copenhagen. 9 × 6 in. Pp. 176, with 14 tables and 98 Family Case Histories. Acta Psychiatrica et Neurologica Scandinavica, Supplementum 76. 1951. Copenhagen: Ejnar Munksgaard. Price D. kr. 20.

This monograph is another of the valuable supplements published from time to time by the various Acta Scandinavica. It gives a very complete account of the progressive muscular dystrophies, with a critical review of the literature of these puzzling diseases and with original observations based on 117 cases collected by the writer. Though mainly of interest to the neurologists and to the specialists in human genetics, this publication has its importance for the orthopaedic surgeon, who will find it a valuable reference book on diseases that he must meet now and then.—D. Ll. Griffiths.

VITAMIN SOURCES IN ARCTIC REGIONS. By Kare Rodahl. Skrifter No. 91. 10½ × 7 in. Pp. 64, with 15 figures and 36 tables. 1949. Oslo: Norsk Polarinstitutt. Price N. kr. 6,00.

THE TOXIC EFFECT OF POLAR BEAR LIVER. By Kare Rodahl. Skrifter No. 92. 10½ × 7 in. Pp. 90, with 36 figures and 15 tables. 1949. Oslo: Norsk Polarinstitutt. Price N. kr. 12,50.

HYPERVITAMINOSIS A. By Kare Rodahl. Skrifter No. 95. 10½ × 7 in. Pp. 206, with 55 figures, 78 tables and 27 graphs. 1950. Oslo: Norsk Polarinstitutt. Price N. kr. 22,50.

The first two Skrifter (Nos. 91 and 92) deal with the historically interesting facts that led to the main investigation. These were: that the liver of seals contained much vitamin A; that the livers of polar bears, largely dependent on seals for their diet, produced severe sickness in man; and finally that this toxicity of polar bear liver was due to its vitamin A content. The third Skrifter (No. 95) then deals with the signs of hypervitaminosis A in experimental animals. These are described in very great detail. Rats were used in most of the experiments, but some were also carried out on guinea-pigs, mice, rabbits and cockerels. The author gives a masterly summary of the facts, and points out how closely in his animals the haemorrhagic signs of hypervitaminosis A mimicked scurvy while the bone changes, as revealed by radiographs, could resemble those in hyperparathyroidism. A great part of this book deals with details of limited interest, such as, for instance, the evidence that polar bear liver is toxic only on account of its vitamin A content and not because of associated compounds. It does not deal adequately with the growing literature on hypervitaminosis A in man. However, as a work of reference it is a valuable contribution to knowledge, especially in these days of widespread vitamin administration.—C. E. Dent.

PHANTOM LIMBS IN AMPUTEES. By Börje Cronholm. 10 × 7 in. Pp. 310, with 40 figures. 1951. Copenhagen: Ejnar Munksgaard. Price D. kr. 35.

In this volume the author has attempted to explain and analyse the common sensations experienced by amputees, whether in the stump or in the phantom limb. Only 122 patients were examined, and the conclusions reached, although adding a little to our knowledge of this highly complex subject, do not point a way to any more certain method of treatment of pain in stump or phantom limb.

It is interesting that only twenty-seven of the patients exhibited painful neuromas, but in many cases there was evidence not only of somato-motor hyperactivity in the stump but also of vegetative hyperactivity in the stump and adjacent parts of the trunk. There seems little doubt that painful sensations in the stump or phantom limb are commoner after high amputations, whether of the arm or leg, and are commoner in those losing the limb late in life when adaptation is more difficult. The investigation also proved that pain in the phantom limb is commoner immediately after amputation, and usually tends gradually to subside. Patients who have lost a limb that has been painful for some time before amputation are also more liable to a painful phantom.

The loss of a limb causes a state of hyperexcitability of the central nervous system, not only at spinal level but also at central level, and some of the phantom sensations can be due only to this excitability. The tendency of a phantom sensation to disappear or diminish proves that there is an attempted central adaptation. This is easier and more complete in young patients—the very young may experience no phantom. It is thought that there is a central "shift" in functional organisation, which conditions the integration and interpretation of the afferent or centripetal impulses from the cut nerves. The sensation of pain appears to be determined chiefly by the intensity of the centripetal volley of impulses, especially from the stump, and by the state of central hyperexcitability; but the localisation of the pain to phantom or stump is determined by the central state of functional organisation, in which the make-up of the patient would seem to be important.

A basic phantom sensation is not present in every case, but some patients can summon a phantom by concentrating on it, by trying to perform movements with it or by contracting the stump muscles or the muscles of the opposite limb. A referred sensation assigned to the phantom can also be caused, and sometimes altered, by various types of stimuli applied to the stump or to "trigger areas" of the stump or adjacent parts of the trunk. Stimulation may inhibit the phantom or may intensify the sensations assigned to it. Sensations in the phantom leg are usually referred to the foot or distal part, those in the phantom arm to the hand or wrist; but in arm cases it is commoner for the phantom to be foreshortened to within the area of the perception of the stump.

The leg phantom usually conforms to the posture of a natural limb, but the arm phantom is more often away from the "natural" position. This is probably because the arm has a more highly specialised function than the leg, and may explain also why the phantom is more often identified with the artificial leg than with the artificial arm. Identification of the phantom with the artificial leg is used in walking—or the phantom may disappear when the limb is worn. The artificial arm, however good and well controlled, cannot approach in function the highly specialised and sensitive natural hand and fingers, so that the "phantom" does not help the use of the artificial arm in the same way.

The sensations after the loss of a limb bear many resemblances to those in peripheral nerve injuries; for instance pain is more common in high amputations, where division is nearer the parent neuron and more fibres are divided. Some of the referred sensations aroused by pressure on the neuroma, or by other stimuli applied to the stump, resemble sensations referred to a painful area after nerve injury. In amputees there are many complex and seemingly contradictory findings not entirely explained by the hyperexcitability of the central nervous system and the retention of a topical distribution of the sensations, nor by the attempt at adaptation by a central shift in functional organisation. Whatever the true explanation of the varied and often unpleasant experiences of some amputees, there seems little doubt that the psychological make-up of the patient affects their interpretation and accounts for the failure of many recognised methods of treatment to achieve lasting improvement in some individuals.

The author is to be congratulated on his painstaking investigation of only a comparatively small number of cases. The translation has made the earlier parts of the book a little difficult to read; but the discussion of the findings, the summary and the conclusions are logically set out and easily understood.—T. Ritchie.

CHIRURGIE RÉPARATRICE ET FONCTIONNELLE DES TENDONS DE LA MAIN. By Claude Verdan. Privat-docent de chirurgie à la Faculté de Médecine; Chef de la Policlinique Chirurgicale Universitaire Lausanne. Preface by Professor Pierre Decker. 9½ × 6½. Pp. 243, with 108 figures. 1951. Index. Paris: Expansion Scientifique Française. Price £2. 4s.

This monograph reads like a Swiss Guide Book. The illustrations are not quite up to the standard of the holiday brochures but its layout is pleasing and sections are easily found. It contains little that is new. It deals largely with observations about injury and the technique of repair. This monograph is probably unique in that in a reasonable compass it states the essentials that are basic to the repair of injured tendons of the hand. It summarises the numerous papers that have appeared recently on this subject and abstracts information from the classical text-books. It is well worth study and is likely to be of use to the surgeon who may be called upon to deal with casual hand injury.—Ronald Furlong.

DIE ENTWICKLUNGSSTORUNGEN DER EXTREMITATEN (6th part of Volume IX in the "Handbuch der speziellen pathologischen Anatomie und Histologie"). By A. Werthemann, O. Professor der pathologie in Basel; Direktor des Pathologischen Institutes der Universitat. 10 × 7 in. Pp. viii + 424, with 270 figures. Index. 1952. Berlin, Gottingen and Heidelberg: Springer-Verlag. Price DM. 103.60.

The entire "Henke-Lubarsch" ("Handbook of Special Pathological Anatomy and Histology" (now edited by Robert Rossle of Berlin) makes a formidable row of volumes. Both in its content and in its presentation it sets the highest standards of descriptive pathological anatomy, and it has been for many years an authoritative work of reference. The present volume, by Professor Werthemann of the University Institute of Pathology at Basle, dealing with "Malformations of the Extremities," is the most recent addition to the series of volumes dealing with the locomotor system.

The types of malformation discussed are nearly all congenital, and the book does not include accounts of any generalised skeletal diseases which may involve the limbs, even when, as in the case of some chondrodystrophies and of osteogenesis imperfecta, these are thought to be related to "developmental" processes. The remaining field of malformations, however, is thoroughly and systematically covered. In contrast with other volumes of the series there is little actual pathological material illustrated, the ease of radiological study and the infrequent opportunities for the collection

of post-mortem material being understandable reasons for this. But the radiological data are always interpreted with regard to the underlying tissue changes, and direct comparisons with clinical photographs and pathological specimens are used frequently and with good effect.

The book will take its place as a very useful reference volume, particularly in relation to rare abnormalities, and as such it should be consulted on occasion by the orthopaedic surgeon as well as the pathologist. Some chapters, including the excellent ones on club foot, on congenital dislocation of the hip, and on the accessory bones of the hand and foot, have more frequent clinical associations and merit considerable attention from all interested in these subjects.—H. A. Sissons.

THE KNEE AND RELATED STRUCTURES. By Philip Lewis, M.D., F.A.C.S., F.I.C.S., Professor and Chairman of the Department of Bone and Joint Surgery, Northwestern University Medical School, Chicago. 9½ × 6½ in. Pp. 914, with 333 figures and 2 colour plates. Index. 1952. London: Henry Kimpton. Price £6.

This book is a vast compendium; the author states that he has co-ordinated and integrated material from the available publications. Some of the book, for example the anatomical and structural section, is pure repetition. The chapter on "Neoplastic Tumors of the Knee" is unconvincing and is a re-hash of the ordinary tumour story that one can find in any high-class surgical journal. These criticisms are mentioned first to bring into relief the value of the book as a whole. It is a monument, meant to last. It denotes erudition and plain hard work. Much of the book is an intimate personal account of what the author practises and preaches. In matters of opinion, the views of others are freely quoted. The book is of formidable size and therefore can only be classed as a reference volume and so will live on a bookshelf. It will be found only in libraries because it costs £6 a volume. When it is referred to in order to find the answer to an unusual problem, the answer will almost certainly be found.—Ronald Furlong.

OSTEOARTHRITIS OF THE HIP with special reference to treatment by vitallium mould arthroplasty. By W. Alexander Law, O.B.E., M.D., F.R.C.S. Assistant Surgeon, Orthopaedic Department, London Hospital; Associate Surgeon, Robert Jones and Agnes Hunt Hospital, Oswestry. 9 × 6 in. Pp. xi + 87, with 31 figures. Index. 1952. London: Butterworth & Co. (Publishers) Ltd. Price 25s.

Mr Law is one of the leading exponents in this country of the operation of cup arthroplasty for osteoarthritis of the hip. The present monograph, which is based on an essay for which he gained the Robert Jones Prize and Gold Medal, is essentially an account of the technique, management and results of his own series of 160 patients, forty-four of whom had bilateral operations. The description of cup arthroplasty is preceded by a brief account of conservative management, including methods of physiotherapy, joint injections and manipulations. Capsulectomy combined with cheilectomy and joint neurectomy are described as alternative but less satisfactory procedures. In the author's opinion a vitallium mould arthroplasty, by Smith-Petersen's technique, "is a sound procedure for relieving pain, correcting deformity, maintaining stability and restoring between one-half and two-thirds of the normal range of movement."

Something less than the first half of this small book is devoted to a consideration of the etiological factors. There is some speculation about the role of arterial degeneration in the production of arthritis in the hip, but on the whole the author produces no new suggestions to explain the high incidence of "primary" arthritis of the hip. He does suggest, however, that relatively slight epiphysial displacement may lead to sufficient distortion to initiate osteoarthritic changes, and it is claimed that the evidence for this can be seen in the radiographs and at operation. Your reviewer remains unconvinced by the radiographic evidence proffered by the author in Figures 7 and 8, but would like to have Figure 5 re-labelled "Old Slipped Epiphysis" instead of "Caisson Disease." The book is nicely produced and well illustrated.

This monograph is of considerable importance as a factual account of an operation that has paved the way for the remarkable developments of arthroplasty operations for the hip.—Norman Roberts.

THE PREPARATION AND WRITING OF MEDICAL PAPERS FOR PUBLICATION. By W. R. Bett, M.R.C.S., L.R.C.P., F.R.S.I. 7½ × 5 in. Pp. 24. 1952. London: Menley & James Limited. Gratis.

This booklet records a lecture given at the Institute of Orthopaedics, and repeated at other institutes of the British Postgraduate Medical Federation, to help its students in the preparation of papers. Of great experience, Dr Bett gives much guidance in searching the literature, arrangement, quotations, illustrations, references, presentation and style. This useful introduction to a large subject is commended to all prospective medical writers.—H. Jackson Burrows.

THE EDUCABILITY OF CEREBRAL PALSIED CHILDREN. By M. I. Dunsdon, M.A., E.B.Ps.S., with a foreword by The Right Honourable George Tomlinson, M.P., Minister of Education. National Foundation for Educational Research in England and Wales. Publication No. 4. 8½ × 5½ in. Pp. x + 163, with figures, tables and graphs. Index. 1952. London: Newnes Educational Publishing Co. Ltd. Price £1, 1s.

Miss Dunsdon's book, "The Educability of Cerebral Palsied Children," is written primarily for those directly interested in this highly complex educational problem, but it has an appeal to a much wider professional and lay circle. In considerable detail, Miss Dunsdon has reviewed the etiology, classification and complications of cerebral palsy with particular reference to the influence that the two main forms have on intellectual development. The high incidence of mental retardation among those with cerebral palsy, coupled with the frequently associated defect of speech, sight and hearing, and occasionally also of emotional stability, retards normal scholastic progress, so that the task presented to the teacher is often formidable.

In a report of this type and scope, it would be unusual if several controversial points did not arise. There are several conclusions which will not receive a universal acceptance. 1) Miss Dunsdon suggests that the dual-purpose schools have failed to justify their claims. Is such a conclusion justifiable on the evidence produced? Failure by one, or even two, schools to show appreciable improvement in their pupils may justify a demand for the trial of different methods, but hardly a condemnation of the entire project. In all dual-purpose schools, the staff must be selected with due regard to personality and temperament as well as to educational attainment, since the work of a school can be ruined by lack of collaboration or understanding between teacher, therapist and scholar. It is only when interest, sympathy and understanding exist between pupils and staff members that the best results will be obtained. The child with cerebral palsy is sensitive to atmosphere, so that strife, or lack of interest in the staff, breeds similar indifference in the pupil. 2) The view that "Among cerebrally palsied children, formal education is unlikely to produce any very satisfactory response, if begun much before the age of about nine years" will not be accepted by many teachers, nor will the experienced orthopaedist agree that physical instruction should hold the centre of the platform until the child is nine, to be replaced in part, or in whole, thereafter by academic pursuits. To accept such a conclusion is to ignore the decided physical improvement that does occur *pari passu* with intellectual progress, even in the absence of all physiotherapeutic care. Several years ago Perlstein drew attention to the non-physical benefits of physical therapy, and, more recently, Carlson has shown that in a somewhat similar manner there are benefits to be obtained from education that lie outside the academic field. The treatment of cerebral palsy is prolonged and calls for many remedies, each contributing its quota to the betterment of the child, one taking precedence over another only where special needs demand it. 3) Many speech therapists of wide experience hesitate to dogmatise so decidedly on the influence of laterality and eye dominance in its effect on the development of speech and training. Other dual-purpose schools in Britain have not been able to support these views of Miss Dunsdon which were first suggested by Phelps. It would have been of interest to know on what number and series of tests Miss Dunsdon determined laterality and how long each case was observed. She rightly divides eye dominance into three groups of right, left and intermediate; yet, when handedness is considered, she ignores an ambidextrous group. This is surprising, because handedness and the ability to concentrate and so benefit from instruction are so often related: the child with a "butterfly attention" is frequently ambidextrous. Although Miss Dunsdon's figures indicate the number of children reviewed under each section, she does not state clearly in the text the basis of selection. As the number of cases varies from chapter to chapter, one assumes that in each the children were selected for the specific disability reviewed. Percentages calculated on such a selected group do not give a true indication of the frequency of each specific disability in the cerebrally palsied

population at large. She is also often guilty of giving percentages without clearly stating the numbers upon which they are based, and in some places percentages are quoted for numbers as low as six. Had Miss Dunsdon given the raw figures and avoided the use of percentages, particularly where these apply to small numbers, the book would have gained in value and statistical clarity.

These few controversial points do not detract in any way from the merits of this report, which is realistic, readable and based on acute observation of a large number of cases. While many will not agree with all the views expressed, Miss Dunsdon must be congratulated on making a valuable addition to the literature on cerebral palsy. This is a book which should be in the library of everyone interested in this subject.—G. A. POLLOCK.

THE SOCIAL WELFARE REVIEW. Year I. October 1952. No. I. Pp. 160, with 15 figures. Contents in Greek and English. 1952. Athens: Ministry of Social Welfare. Price not quoted

"The Social Welfare Review" is a new monthly publication of the Greek Ministry of Social Welfare. The first number contains fourteen essays on the various stages of rehabilitation of the physically disabled. Each article is summarised in English at the end of the journal.

The Minister (at the time of publication) and Mr Goutos outline the programme arranged for the nearly thirty thousand disabled in a country with a population of seven millions, which is recovering from ten years of warfare. Dr Pournaropoulos writes an interesting history of the disabled, which is illustrated. Various authors devote chapters to many of the problems of children and wounded. One essay discusses the State care of the civilian disabled, a very difficult problem in Athens where there is a beggar at every street corner. Dr Harold Balme makes a contribution; and Miss Rachel Collier, an after-care sister who has been in Greece for over two years, writes on physiotherapy.

This publication is welcome in that it shows the effort being made to assist the disabled in a country ruined by wars and fever. The technical and financial assistance given by other countries has been appreciated by the Greek Government, which has dealt in a non-party way with the social problems, in spite of great difficulty. It seems likely that World Health Organisation has cleared the country of the mosquito, so that the scourge of malaria will no longer ruin the physical and mental conditions in Greece. This journal indicates that one social problem is under control, although four years ago it was not understood. The Ministry and Mr Goutos are to be congratulated on their work and the publication of this journal, both of which are an example to small nations.—St J. Dudley BUXTON.

HANDBOOK OF ORTHOPAEDIC SURGERY. By Alfred Rives SHANDS, Jun., B.A., M.D., Medical Director of the Alfred I. du Pont Institute of the Nemours Foundation, Wilmington, Delaware, in Collaboration with Richard Beverly RANEY, B.A., M.D., Professor of Surgery, University of North Carolina, Chapel Hill, North Carolina. Fourth edition. 9 × 6 in. Pp. 644, with 192 figures. Index. 1952. London: Henry Kimpton. Price 60s.

I like this book; for, although I may not agree with all the views expressed, that does not mean the views are wrong, and although the book may not be perfect there is in it a quality of perfection. What, after all, is the perfect text-book for the student? It must, I believe, be a book neither so large that he will become confused and lost, nor so small that his sense of proportions will be abused. It must reflect an open mind and yet be stiffened by appropriate authority; so that the student may be intrigued by implied controversy and yet nevertheless gain a foundation of accepted knowledge. Finally—and this is surely the most important—the book must present its contents clearly, that the student will be able to understand, and interestingly, that he may be stimulated to inquire. Now this handbook entirely encompasses the modest objective it has set up; its illustrations are reasonably representative, the legends are realistic and the pattern of the book is clear and extremely practical. It is amazingly comprehensive for its size, and this is achieved by economy of words—always an attractive feature if, as in this instance, clarity is preserved. Also preserved is a balanced outlook, which seems to me the same as a sensible attitude and implies good surgical judgment. For example, take the section on Dupuytren's contracture (page 538). What more could you want? My pet theory perhaps, or yours; but what of it?

Or take the mallet finger (page 540). We might have been told how the term "mallet" arose (Goronwy Thomas is always grumbling that the deformed toe is likened to a hammer and yet the finger to a mallet). And I don't think it would be unreasonable for American printers to drop the word "Roentgenographological" in exchange for "radiological." But these are trivialities, in no way detracting from the real solid worth of this excellent handbook, which is sane and safe, just right for the young surgeon. So, as I say, I like this book.—Bryan McFarland.

THE SPREAD OF TUMOURS IN THE HUMAN BODY. By R. A. Willis, M.D., D.Sc., F.R.C.P., Professor of Pathology in the University of Leeds; formerly Pathologist to the Alfred Hospital, and to the Austin Hospital for Chronic Diseases, Melbourne. Second edition. 10 × 7 in. Pp. ix + 447, with 85 figures. Index. 1952. London: Butterworth & Co. (Publishers). Price 63s.

Recent interest in his "Pathology of Tumours" and "Principles of Pathology" has given Professor R. A. Willis the opportunity of preparing a second edition of his earlier book "The Spread of Tumours in the Human Body." In its first edition, published in 1934, this work was a monograph of the Baker Institute for Medical Research of the Alfred Hospital, Melbourne, where its author was Pathologist for fifteen years. At that time the spread of tumours was a subject of some mystery, being little understood by many of those who dealt with cancer patients. To-day, largely because of Willis's work, the subject is less controversial, and both clinicians and pathologists are much more aware of its bearing on the diagnosis and treatment of cancer. The second edition comes from Leeds where Professor Willis now has charge of the University department of pathology, and its appearance establishes the book as the standard presentation of the subject. The "Spread of Tumours" is based on an analysis of the author's 500 consecutive cancer necropsies. It defines and fully describes the metastasis of tumours, discussing the anatomical pathways (lymphatics, blood-stream, serous cavities, etc.) by which dissemination can occur, and gives an account of the varied ways in which metastatic tumours can produce signs and symptoms. Particular stress is laid on the "latent primary," a study of metastasis revealing how frequently these, and not the primary tumour from which they have arisen, are responsible for the presenting manifestations of malignant disease.

Those concerned in orthopaedics will be particularly interested in the sections discussing metastatic tumours of bone. Evidence regarding their frequency and distribution is presented, and an important section leads to the conclusion that these tumours invariably reach the skeleton by blood-stream dissemination. The nature of "Ewing's tumour"—a subject on which Willis has contributed a number of critical papers—is discussed: the role of metastasis, either from neuroblastoma or carcinoma, in producing the "syndrome" is stressed, Willis's view being that few of the tumours to which this name is attached are primary in bone. But, quite apart from its bearing on the understanding of bone tumours, the book should be read because of its outstanding interest as a general outline of the pathology of tumour spread. Chapters such as "Metastasis by the blood-stream." "The cancerous thoracic duct," "Transcoelomic metastasis," "Latent primary tumours," and "Secondary tumours of the liver," are gems. Accurate, informative and clearly written, the book is always stimulating, and has needed surprisingly little addition or alteration after nearly twenty years.—H. A. Sissons.

THE FOOT. By Norman C. Lake, M.D., M.S., D.Sc., F.R.C.S. Senior Surgeon and Director of Surgical Division, Charing Cross Hospital. Fourth edition. 8½ × 6 in. Pp. v + 466, with 166 figures. Index. 1952. London: Baillière Tindall & Cox. Price 25s.

This book has a wide circulation, especially amongst chiropodists, and it is therefore important that it should be authoritative. Many of the subjects dealt with are difficult and controversial, and, even though Mr Lake has not taken into account the latest work on gait and on the physiology of muscle, he does make a determined attempt to present some of the newer views about posture; but it is somewhat vitiated by his unwillingness to surrender his allegiance to the older ideas and this at times makes his argument rather difficult to follow. The descriptions of the straightforward disabilities of the foot are clear and accurate and should be of value to both surgeon and medical auxiliary, but the accounts of the more controversial subjects might well mislead those who have not made a special study of the problems.—Philip Wiles.

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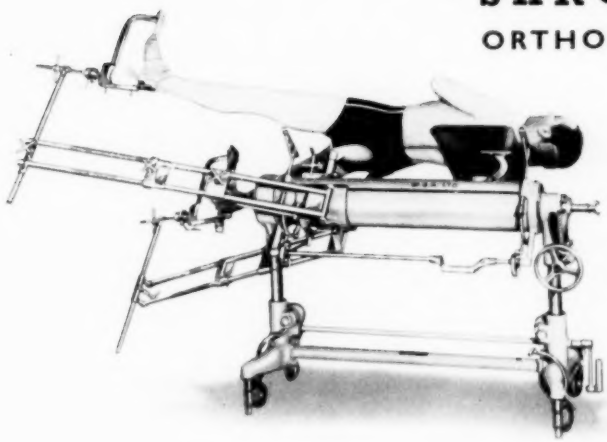

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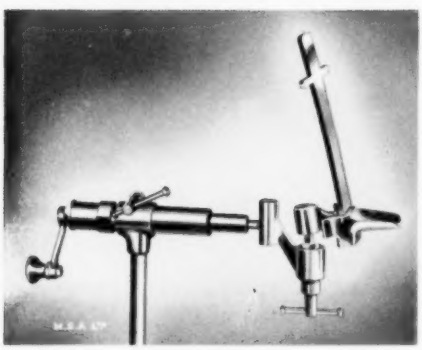

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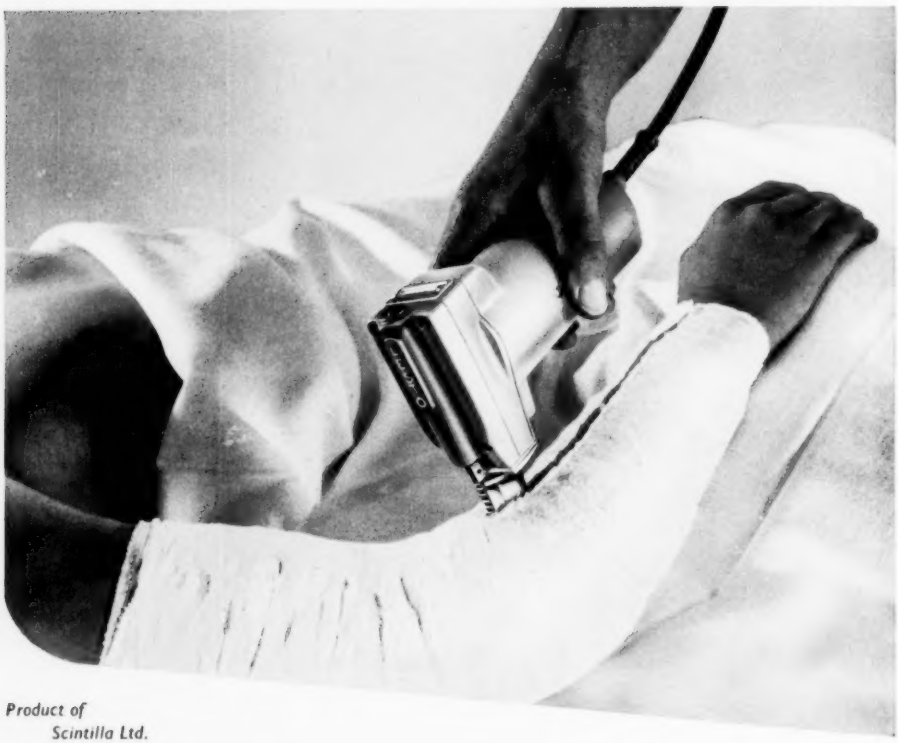

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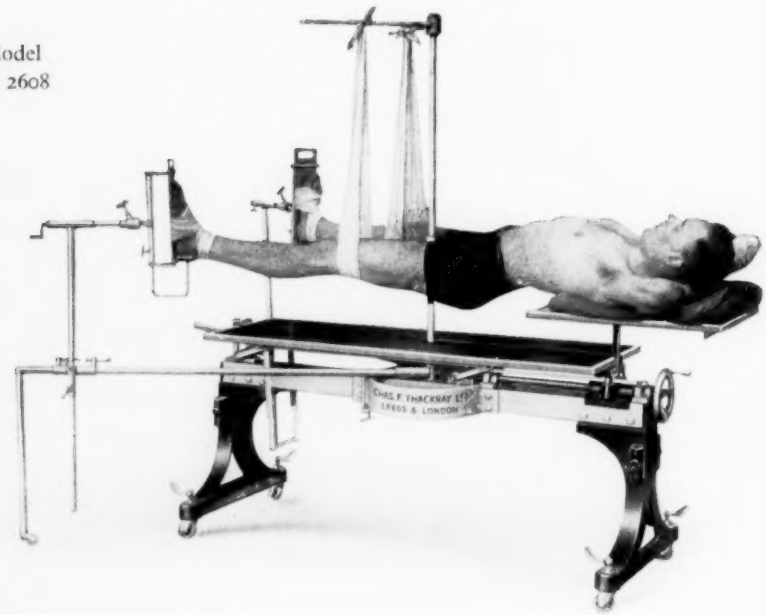

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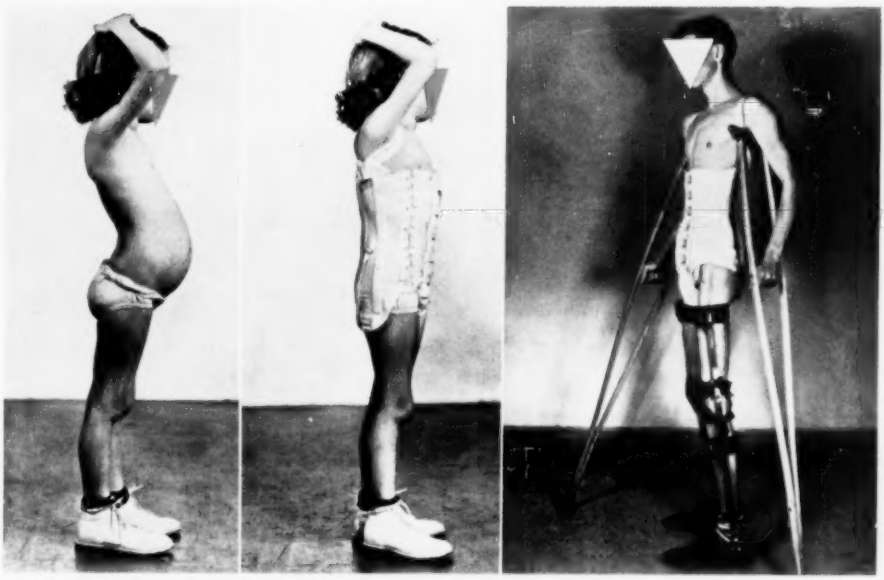

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Treatment for both these patients included Spencer Supports (as shown) to help maintain correct body alignment and to help prevent further development of deformity. For both patients, a Spencer Abdominal Spring Pad* was incorporated in the supports to aid respiration and to compensate for paralysed abdominal muscles.

Spencer is the support of choice because: each Spencer Support is *individually designed, cut, and made* according to the medical indications for each patient.

* Patented

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NEUFELD TYPE

NOW AVAILABLE IN RESPONSE TO THE DEMAND OF THE MANY SURGEONS WHO ASKED FOR THEM

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Effective fixation with Vitallium Neufeld-type nail-plates results in a feeling of security, better patient morale and shorter hospital confinement.

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Together with the Vitallium Jewett and McLaughlin-type inter-trochanteric appliances, the various Vitallium hip nails and screws, the Vitallium ready-made hip prostheses and the Bosworth-type splines, the addition of this Neufeld-type trochanteric nail-plate to the ever-increasing line of Vitallium surgical appliances provides the surgeon with a wider choice of fixation and repair appliances for the upper femoral region than is available from any other source.

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5. Sub-trochanteric fractures
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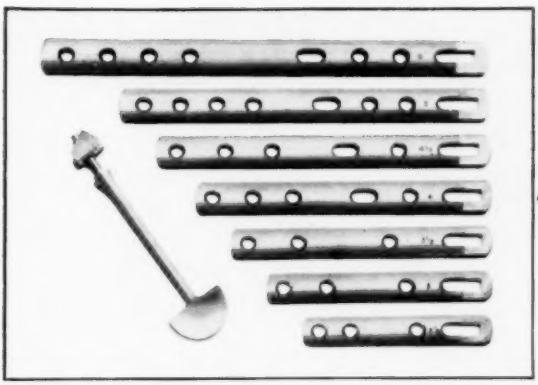

Keeping in step with the requirements and techniques of the nation's foremost surgeons are these three of the newer items in the extensive line of Vitallium Surgical Appliances. Each has been designed by the initiating surgeon to serve a definite need.

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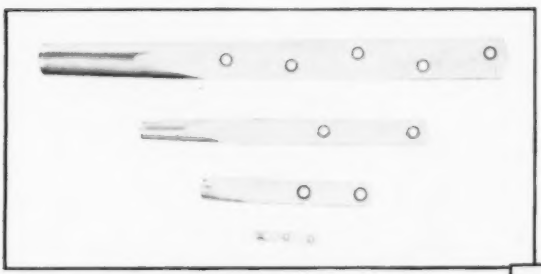
The Coaptation plates are used to impact the fracture ends forcefully and hold them firmly impacted. Such impacted coaptation facilitates uninterrupted blood supply to the traumatized bone cells and promotes early bone healing without excessive callus formation.

The Coaptor is a necessary tool in the application of these plates. Plates are available in seven lengths of 2½ to 6 inches.

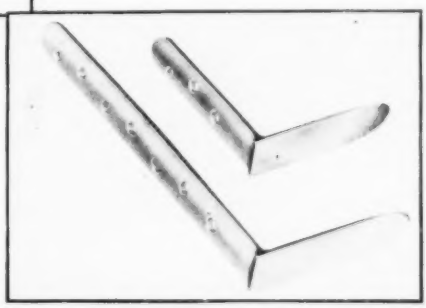


KNEE PLATES *Wright Type*

These acute-angled blade-plates are useful for fractures about the knee, especially supra-condylar fractures, "T" fractures, tibial plateau fractures and distal spiral fractures of the femur. The blade section is driven into the condylar area and the plate screwed to the femur or tibia for a simple, effective fixation.

SPLINES *Bosworth Type*

In 8" (adult) and 5" (children) sizes for geometric osteotomies of the hip. The sharp end is driven through the trochanter into the head of the femur and the spline is attached to the shaft, unbent, in a direct vertical weight bearing position. In 3" size for fractures of the surgical neck of the humerus and for humeral osteotomies. The spline is bent to the appropriate angle driven into the humeral head and screwed to the shaft. The 1" finger spline is for fractured metacarpals and metatarsals and can be bent as desired.



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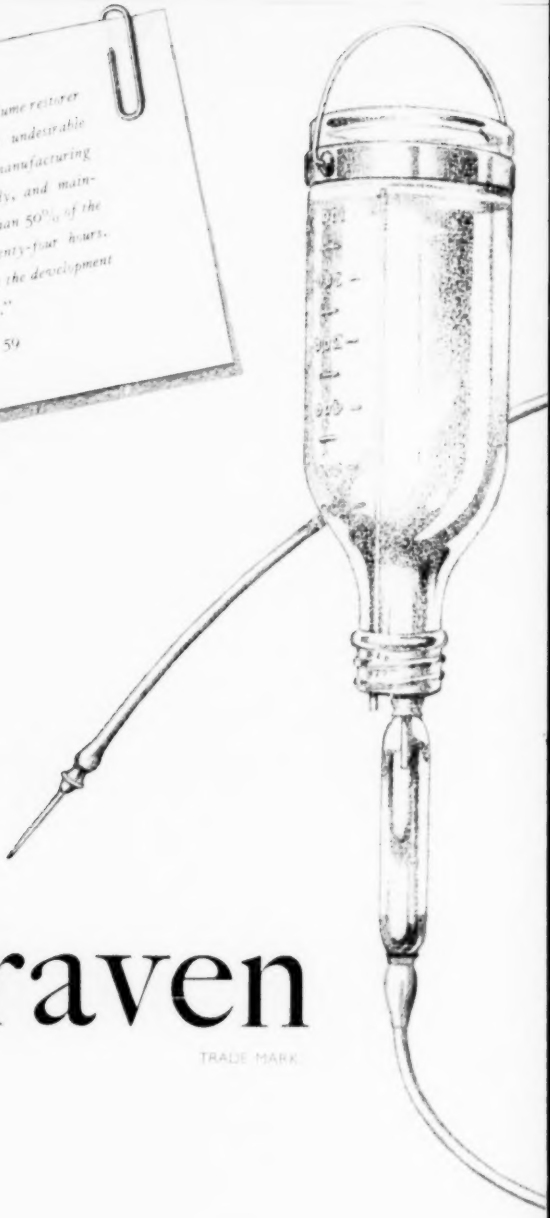
Lancet, 1953, 1, 59



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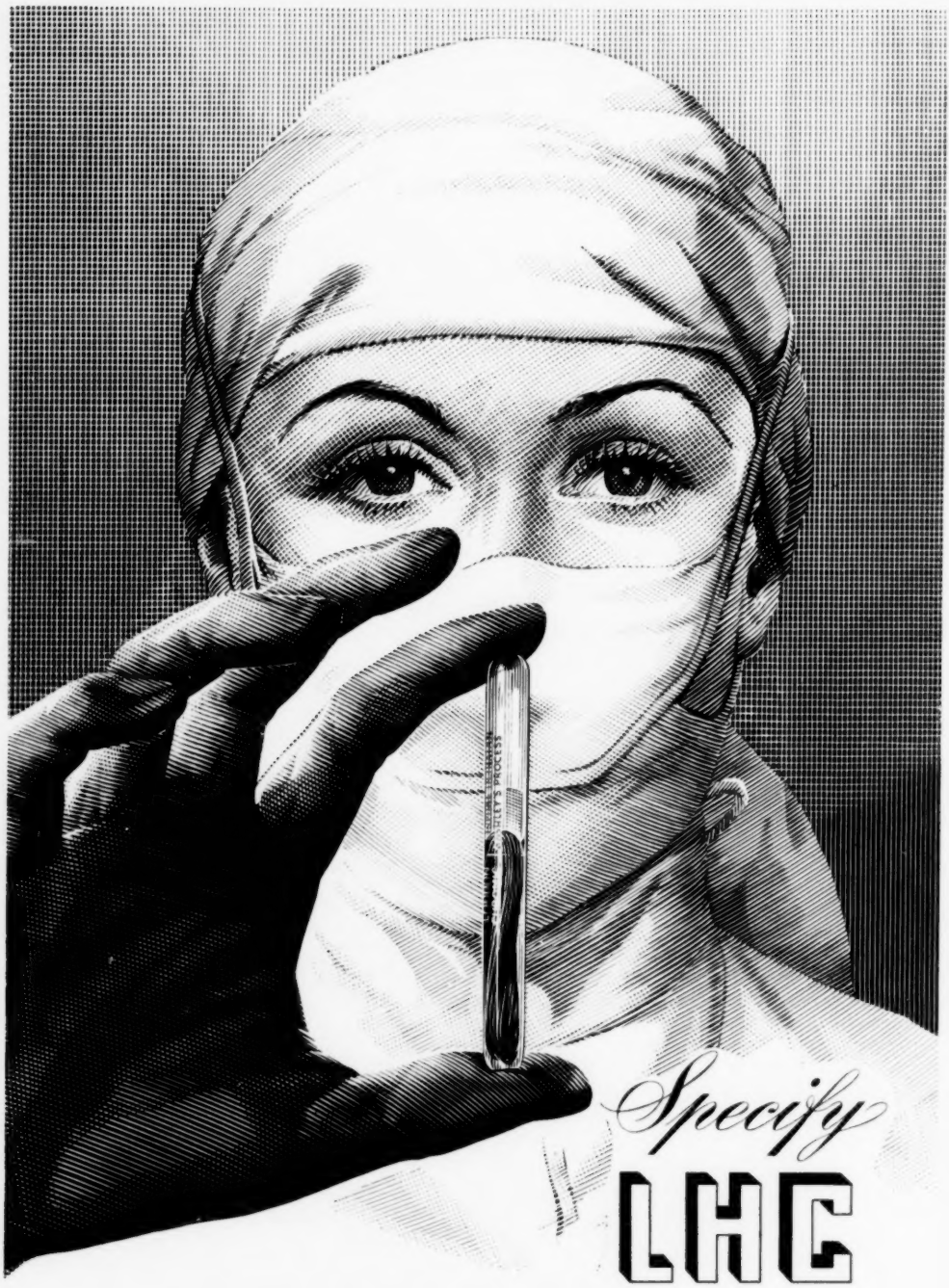

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DAILY MAIL—Jan. 20

ILFORD ENDS THE X-RAY FILM SHORTAGE

By L. D. WILLIAMS, City Editor, 7, ANGEL-COURT, E.C.2. Tel.:

YESTERDAY Mr. Wilfrid Hampden Dimsdale, joint managing director of Ilford, Ltd., told in London of the completion by this ... material manufactur... cern, of a £1,250,000 ... tion plant for makin... film base in this cou...

This will have importan... ages for the company's ... and for the national pa... effort.

It will make the compa... pendent of foreign suppli... X-ray film base has in the p... imported from the U.S. a... small extent from Belgium ...

The new enterprise will as... £1,000,000 a year in dollars ... It will be possible for Ilf... greatly increased production ... its exports, there will be sub... foreign currency earnings.

From the standpoint of th... try's balance of payments it ... cut to pick on a more promis... of domestic capital investme... a one-and-a-quarter-million ... prise that will bring the eq...

CITY

THE TIMES—Jan. 20

INCREASING DEMAND FOR X-RAY FILM

NEW PLANT TO END SHORTAGE

Miss P. HORNSBY-SMITH, Parliamentary Secretary, Ministry of Health, said yesterday that the use of X-ray film by the national health service had increased annually since 1948 from 11,700,000 sq. ft. to 16,000,000 sq. ft. at present. Never before had the demand for X-ray film been so great. Miss Hornsby-Smith was speaking at a luncheon at the Savoy Hotel given by Ilford, Limited, to mark the company's expansion.

...mpany gave details yesterday of the ...on of two plants at a cost of ... designed to end the shortage of ... which, in recent years, has been a ... to hospitals and has slowed down ... pects of ...ical research. At Ilford ...ny has ... additional film-... with BX ...nit, an... ...ant has ...limited ...ructu...

EDINBURGH E. DISPATCH—Jan. 20

PROJECT WILL BOOST X-RAY FILM OUTPUT

A project which should overcome the shortage of X-ray film has just been completed by Ilford Ltd., the photographic film manufacturers, at a cost of £1,250,000.

The scheme includes a film-coating unit of the most modern design and the building in Essex of a plant for manufacturing film base.

Both plants were timed to come into operation simultaneously, so that the film base, never before produced in Britain, could enable the firm to increase output of X-ray film.

This, with the additional coating unit, will almost entirely eliminate dollar spending, it is claimed.

In the past, nearly all X-ray film base has been imported from the United States, with small ...antities coming from Belgium. At present, Ilfords are Europe's ...gest makers of X-ray film, the ... in this country being ...

YORKSHIRE POST—Jan. 20

New plants to end shortage of X-ray film

From our industrial correspondent, ROBERT SCOTT

Two new manufacturing plants, recently constructed at a cost of £1,250,000, will end the shortage of X-ray film in British hospitals.

The London firm of Ilford, Ltd., announced yesterday that they had installed an additional film coating unit of the most modern type. With BX Plastics, Ltd., they had also constructed a new plant for manufacturing film base. This twin project would end the shortage of X-ray film which had handicapped British hospitals in recent years and ... various aspects of medical ... The company point out th... port, all X-ray film base ... imported from the United S... small quantities from Belg... represented a third of the ... of manufacturing X-ray ... since the introduction of ... Health Service had cost ... nearly 2,000,000 dollars a ...

The two new plants w... come into operation sta... so that the film base ... processed in Britain, coul... company to increase it... It is hope...

MANCHESTER DAILY DISPATCH—Jan. 20

New film plant will save dollars and aid X-rays

"Daily Dispatch" Reporter

THE birth of a new industry that will save—and earn—millions of dollars for Britain through the home manufacture of film-base was announced in London yesterday. Mr. W. H. Dimsdale, managing direc... and ch...

...of radiation to which they have been exposed.

The two new plants comprise an additional film-coating and a new factory for ...turing film-base.

DAILY HERALD—Jan. 20

INDUSTRIES CUT QUEUES FOR X-RAY

BECAUSE British industry ... imports of plastic base from the United States and Belgium.

Twin projects by Ilford, Ltd., and B X Plastics mean that there will be no shortage handicapping hospitals, hampering medical research and slowing the use of

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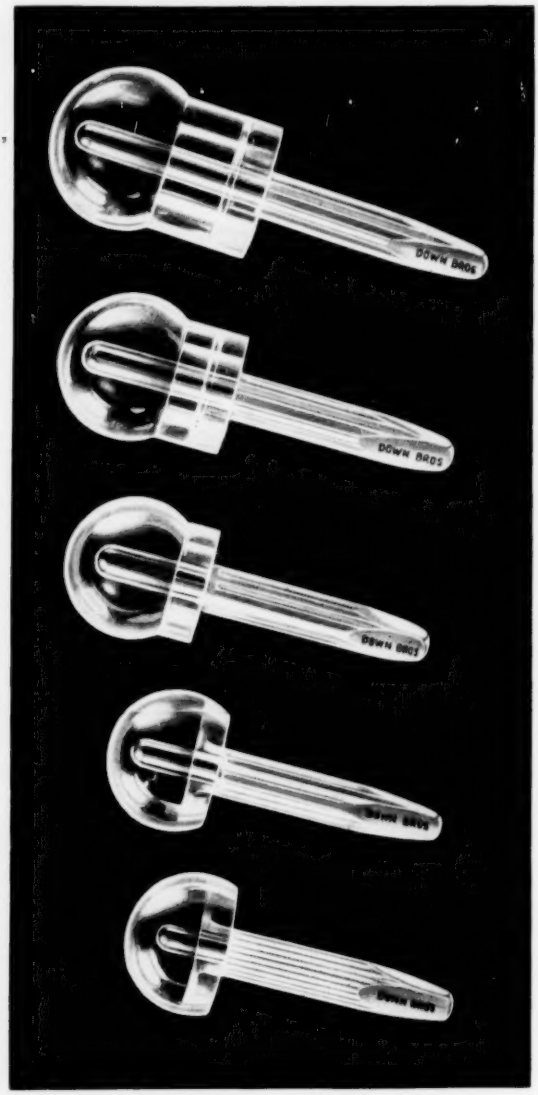

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Glassona Feather-weight cast withstands weight of 19-stone patient

A transverse metatarsal fracture of the right foot in a man weighing 19 stones was treated by the application of a below-knee plaster cast.

After 7 days the cast broke down owing to the excessive weight of the patient.

Over a period of 11 weeks four new plaster casts were applied and one repaired. *No* cast was strong enough for the patient's weight.

The below-knee Glassona cast was applied, and the patient discharged to the out-patients' department.

The result was satisfactory, the patient returning to work wearing only an over-boot without walking appliance. The cast was retained for 7 weeks, needing only repair underneath through wear—on removal the fracture was united.

This actual case graphically illustrates the exceptional strength and toughness of Glassona the new feather-weight splinting material.

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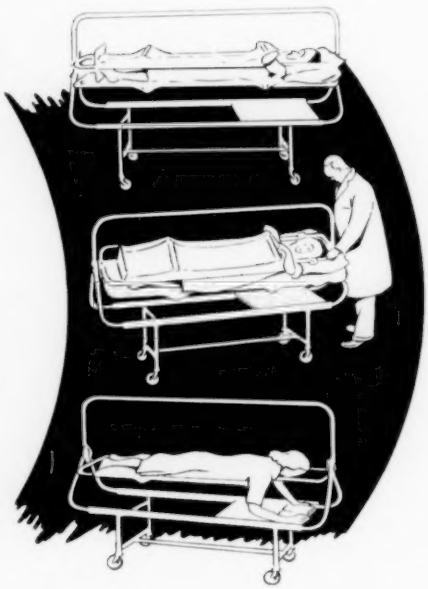
—it enables the patient to be turned easily and with little effort from the supine to the prone position; or vice versa.

THE "Emesay" TURNING FRAME

THIS IS AN IDEAL APPARATUS for nursing which overcomes the many difficult problems presented in cases suffering from burns and paralysis; in the post-operative treatment of spinal and pelvic fracture and spinal fusion, and in any instance where it is necessary to maintain the patient immobile with an absolute minimum of handling.

A strongly constructed steel framework with its special canvas beds gives firm support together with comfort for the patient, whilst facilities for bed-pan service, urination, and drainage are provided.

The sliding platform below can be used as a table top for feeding or reading by the patient when lying prone.



An illustrated informative folder is available on request from the manufacturers.

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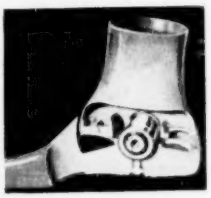

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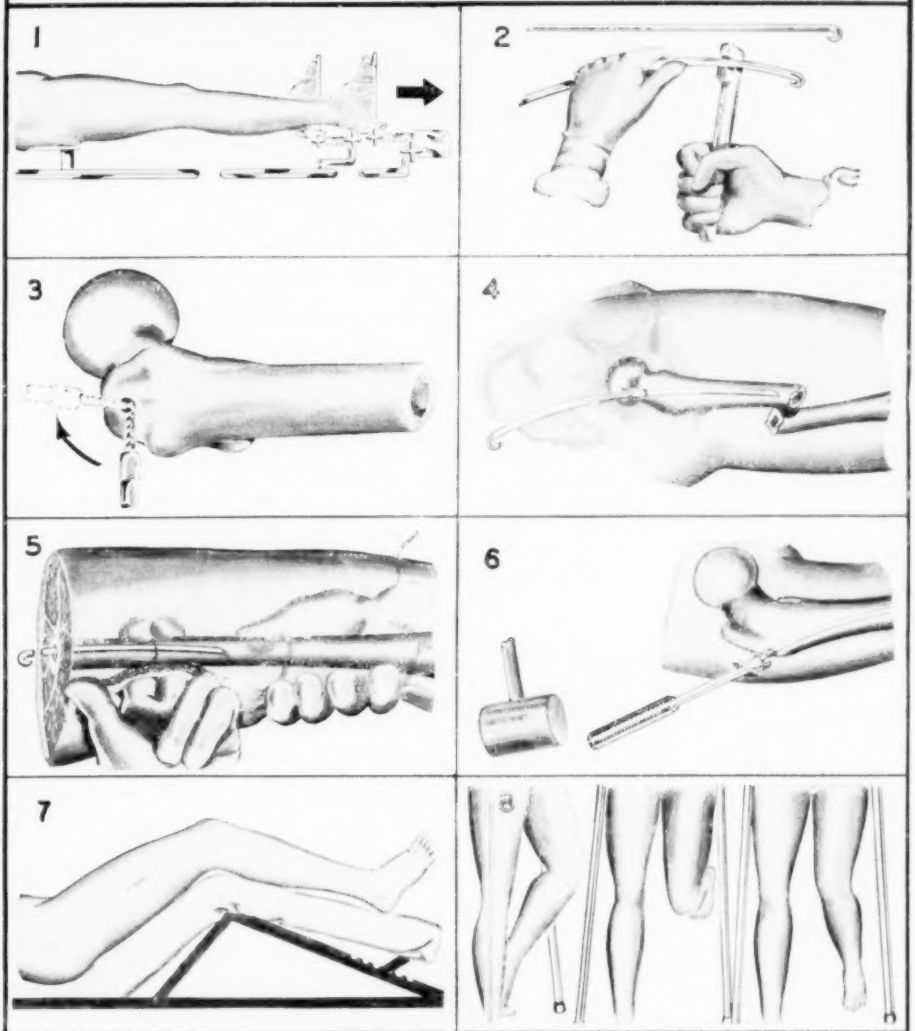

REFERENCES: RUSH, L.V., AND RUSH, H.L., *THE MISSISSIPPI DOCTOR*, SEPT., 1949; *THE AMERICAN JOURNAL OF SURGERY*, SEPT., 1949

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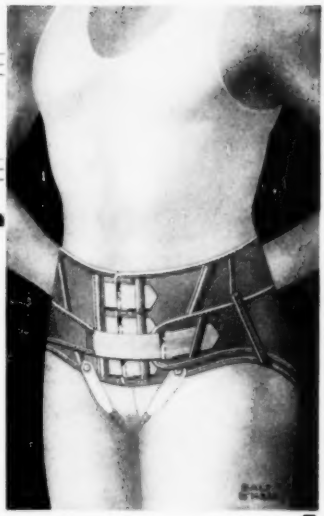

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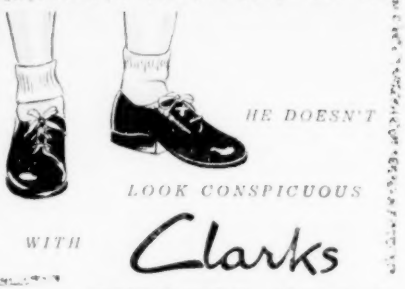

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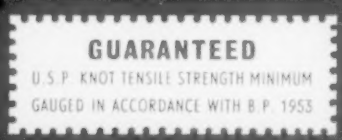

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